SILICON CHIP

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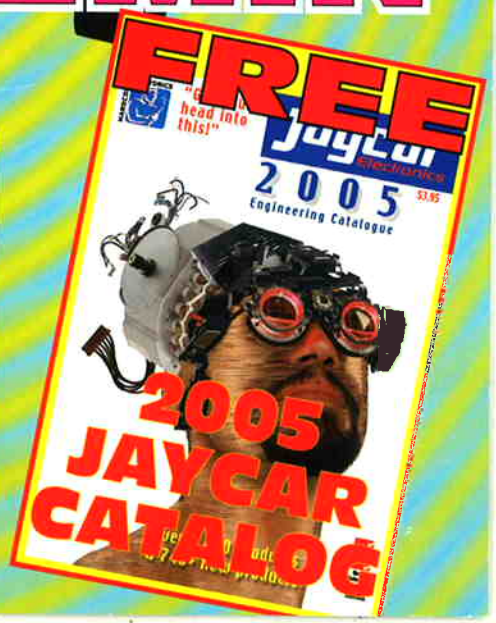

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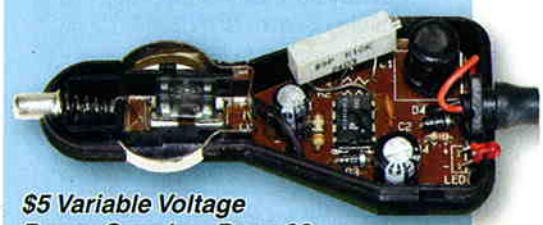

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Publisher's Letter

Reader feedback is welcome

This month, as in all months, we have some very good letters from readers, on a diverse range of topics. As you will see in the Mailbag pages starting on page 4, some are very complimentary and others, well . . . you can see for yourself.

In particular, my answer to David Millist last month on the topic of current transformers brought forth a torrent of letters, both by email and by post. David Millist can take a bow because all the letters rushed to his defence.

I must admit to being taken aback by the vehemence of some of the letters – we have only included a selection – and I thought "Oh dear, what have we unleashed this time?" As I went through the letters and talked to a few older readers, I realised that in stating that we failed to see how a current transformer can generate lethal voltages, I had completely overlooked the common type of current transformers widely used in power distribution systems. If an open-circuit occurs in the secondary winding, such transformers can be very dangerous indeed.

And of course, after we ran a few current monitoring lashups, I had to admit an error in the operation of toroids. Expletive deleted.

On reflection, I realise that such rapid feedback from readers, immediately after an issue has gone on sale, is a good thing. Many thousands of readers take SILICON CHIP very seriously indeed and are anxious that we continue to maintain a high standard. We like getting the compliments and therefore we must also accept the criticisms when they come.

I particularly like the fact that so many readers comment on the answers in "Ask SILICON CHIP". Readers enjoy most sections of the magazine, but "Ask SILICON CHIP" consistently generates far more correspondence than any other section, both in questions asked and comments on the resulting answers.

We have always known that our readers are vigilant, which is why I hate it when errors do appear in the magazine. That is one of the drawbacks of a print magazine – when an error occurs, it is there for all time. We can and do publish Notes & Errata but the error still remains on the printed pages. An on-line publication is different; if an error occurs, you can do a quick up-load and presto, it might never have happened.

But our long-term destiny appears to be with the print magazine. While the on-line version of SILICON CHIP is popular with many people, the vast majority appear to favour the printed edition. It is so much easier to read, to digest and refer back to, and to spot those loathsome errors!

Leo Simpson

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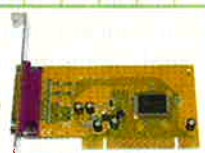

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MAILBAG

Desalination water costs are wrong

The costs you quoted in the March editorial for WA's desalinated and piped water were surely not as shown? They correspond to about 50c and $1.50 per litre! This is as high as the bottled water racket charges on our supermarket shelves.

On the subject of loud DVD background music, my thanks to Graham Johnston (Mailbag, March 2005). I do not use an amplifier but I find that by connecting the centre audio channel to one of the TV speakers and making no connection to the other, nearly all the music is suppressed and the dialog is very clear.

Robin Stokes,
Armidale, NSW.

Comment: three people proof-read that March editorial – they must be blind! The figures should have related to a kilolitre of water!

Disagreement on current transformers

David Millist wrote regarding current transformers (March 2005, page 6) and I wish to disagree with your comment on this matter. Referring to open circuit secondary voltages being dangerous, I enclose a copy of a relevant page from a text book used in gaining the Electrical Engineering Certificate from NSW TAFE during the 1960s, which included the Electrical Measurements option. It does indicate some danger to persons and equipment and the reasons behind it.

With regard to the one conductor through the core being considered as a full turn, many students question this but the lecturers were adamant that it was correct and that it definitely could not be treated as a "half turn". Unfortunately, age has blunted the memory and I am unable to elucidate the theory. Nor can I find any clear reference in the several texts which I have retained covering the subject.

In my work with current transformers used in test equipment, it was usual for there to be a link or simple switch provided on the transformer to facilitate short circuiting the secondary and the work instructions were quite clear "DON'T FORGET TO SHORT BEFORE OPENING THE SECONDARY CIRCUIT".

Peter Grout,
Forestville, NSW.

Current transformers generate high voltage

I must agree with David Millist – ***current transformers*** (Instrument Type at least) ***must*** never have an ***open*** secondary as they generate high voltages.

This was one of the first things I was taught as an apprentice in the electrical generation/distribution industry some 35 years ago.

I have checked various reference books, such as Newnes Electronics Engineer's Pocket Book 1996, and page 16 carries that very warning! It also explains why!

It is a shame your "comment author" did not check the facts before commenting!

Another electrical hand book clearly states: "The secondary must be short-circuited if the ammeter is removed for servicing". What a shame they have made such a basic uninformed mistake!

Michael Abrams,
Capalaba, Qld.

Current transformers can be lethal

I read the letter from David Millist on current transformers and your reply. I am inclined to agree with Mr Millist. The secondary voltage of any transformer is (if I've got it right) actually proportional to the time rate of change of the flux – ie, $d(\phi)/dt$ – which *most* of the time is proportional to the primary voltage.

The output voltage of a current transformer loaded with a resistor is proportional to the product of the secondary current and the load resistance, so in the extreme case when the load resistance becomes infinite, one might expect the secondary voltage to become infinite as well. Of course, this won't happen in the real world as other effects come into play.

Furthermore, the burden of a current transformer will increase if it is not terminated, so the primary voltage will increase in such circumstances, and less voltage will be dropped across the load whose current is being measured.

So high voltages can be generated at the secondary terminals of a current transformer if it is not terminated with a low enough impedance. Whether they are lethal will depend on the particular circumstances. I reckon that in many cases the shock might be unpleasant at least. The source impedance of a current transformer (essentially the secondary winding impedance) is pretty low, so one would expect that they could deliver currents that might be lethal.

The issue is whether enough voltage can be sustained long enough for a lethal current to be delivered. Lethality of a current depends on its magnitude and the length of the exposure.

On the issue of full or half turns in a toroid, David Millist is quite correct. It is not possible to use a genuine toroid core with anything but an integer number of turns. The wire through the centre might appear as half a turn but the turn is completed in the outside world. Non integer turns are only possible in cores with more than one hole (such as the E-I form common in mains power transformers). Two holes can give half turns, three holes could give a third of a turn, etc.

Phil Denniss,
University of Sydney.

Comment: ahem, hmm (gulp – large slice of humble pie required to be eaten here). OK, since people have been so adamant about this, we had to go and do some actual tests. Never mind theory – what happens in practice?

We did a number of tests with toroidal power transformers to simulate the effect of a straight wire carrying 1A through the centre of the core. These tests were quite unequivocal – a straight wire is exactly equivalent to full turn, not a half turn. We repeated the tests with a clamp meter and again, the result was exactly the same. So yes, we were wrong!

On the question of current transformers though, we plead not (so) guilty. Our answer is still essentially correct. It appears that readers have assumed that we are talking about current transformers used in power distribution systems whereby very high currents are monitored by a moving iron ammeter in the secondary of the current transformer.

Certainly, these transformers can be very dangerous if the ammeter is disconnected while current flows in the primary. In fact, the voltages can be high enough to destroy the transformer itself. In really big current transformers, there is even the risk of a violent explosion if the ammeter connection in the secondary is inadvertently broken.

But in our reply to David Millist, we did not think about such large current transformers. After all, not many electronic enthusiasts have access to such beasts! Our original answer relates to a letter on page 98 of the January 2005 issue and is about a flea-power transformer to drive a high impedance multimeter. Nor did we suggest the specific figure of 1000 turns, just many turns.

However, as part of our tests, we measured the voltage from the 240VAC primary of a 160VA transformer which actually had 1024 turns. With the same 1A wire through the centre of the toroid and using the 240VAC primary as the secondary, the output voltage was 18.5VAC into a 10MΩ load – ie, a digital multimeter – and 6.2VAC when loaded with a 10kΩ resistor.

From that, if the wire carried 10A, you could expect 185VAC into 10MΩ and 62VAC into a 10kΩ load. So yes, the voltage into an open circuit is much higher, as we would expect, but again even this is a much bigger current transformer than our original answer suggested.

In hindsight, we should have been more specific in our original answer. If we had suggested, say, 50 or 100 turns on the secondary, it would have been quite sufficient to drive a high impedance (10MΩ) digital multimeter.

Current transformers operate in a different mode

In your reply to the letter on Current Transformers in the March 2005 issue, you state that you cannot "see how a current transformer can generate a dangerous voltage unless it has a significant voltage across its primary". The problem with current transformers is that they operate in a different mode to the basic voltage transformer that most people are used to – and the expected transformer ratio rules simply don't apply!

For a current transformer, the core flux depends on the primary current (as per a voltage transformer) and also on the flux, generated by the secondary current that, according to Lenz's Law, cancels out most of the primary flux, leaving the core with a low level of total flux, and a low generated EMF in the secondary winding. (CTs typically run with low core flux levels compared to voltage transformers, and so generate no more than 5 -15V at maximum primary and secondary current.) CTs with no load have a primary flux but do not have an opposing secondary flux, so the basic voltage transformer operation, as well as the normal transformer rules cannot be applied to them.

This occurs because, if you open the secondary and power up the CT primary, the primary current will drive the core flux to quite high values, as there is no secondary flux to oppose and reduce the primary flux, and these high flux levels in the core generate high EMFs in the secondary winding, which may have hundreds of turns in larger (commercial) CTs. In many instances, low ratio CTs – 50:5 (ie, 50A primary to 5A secondary), or 100:5 – can yield over 100V across the secondary terminals and in the case of high ratio CTs (2000:5 or 5000:5), several ***thousand*** volts are common. This can cause flashovers and in the case of oil-filled CTs used by the supply authorities, has led to explosions and fires on occasions.

Although the CT in the project mentioned is not capable of these

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See JED's www site for a datasheet.

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effects, it may generate voltages that *do* exceed Extra-Low Voltage (32V AC) and so may present a hazard to electronic devices to which they connect or they may "bite" an incautious service person hard enough to cause dropped tools, with possible short-circuit problems and naughty sailor-type words from the lips of the startled technician.

So David Millist's statement that CTs can and will generate lethal voltages with an open circuit secondary is quite correct. The "lethal" applies mainly to commercial CTs as you know but you cannot apply the "logical" voltage transformation rules to a CT to understand the reason for those high voltages!

Secondly, a "half-turn" through a CT core *is* effectively a single turn – if you draw a sketch of a single turn passing through a toroid, *all* of that turn's flux expands out and enters the core, and generates an EMF. The permeability of the core, with no air gaps, gives up to 2000 times the flux in the core that a conductor surrounded by air would generate, so any conductor *inside* the core is very effective. But if you place the same conductor outside the core and sketch its flux path, the flux may enter the core on the side nearest the core but it must leave the core *before* passing all the way round and has to expand *away* from the core, through air, on the side remote from the core.

That means there's a very large air gap in the magnetic path *outside* the core, which gives a low relative permeability (typically slightly more than unity) for the flux path and hence low flux generated in the turn outside the core. That, in turn, means that the side of the turn outside the core has almost no effect in generating voltages in a core with a "closed" flux path!

Only an E-I core or double C-core will use both sides of a turn and hence have "half-turn" capability. Toroids or single C-cores only use the part of the turn inside the core to generate useful flux, generally, so a "half-turn" counts as one turn, really!

Of course, this doesn't apply to air-core inductors (RF transformers, etc) where the absence of the iron core means all core permeabilities are unity. Nor does it apply to RF and IF transformer "rod-type" ferrite cores. This is because this type of construction always has large air gaps around the coils, with the core inside the turns and no "easy" flux path. This means that all flux paths have about the same (low) permeability, and "partial" turns *do* have a proportional effect.

Brian Spencer,
Seaford, SA.

Comment: oh, well – see our previous comment.

Thanks from East Hills Girls

Just a short email to thank Ross Tester and the staff at SILICON CHIP for your excellent article on the PED-X project in the February 2005 Issue. The article has provided the greatest boost for both our students and the school community. It has show-cased what a small group of our students are capable of achieving with very limited resources, especially time. They were particularly proud to have their photo in print and also on the internet.

This year is also the first time that the school has run a year 9 electronics class. It is proving to be quite a success. We were surprised just how many girls are involved in electronics in one form or another, outside of school.

Steve Sharp, Head Teacher,
Information & Communications Technology, East Hills Girls Technology High School, NSW.

Better method for setting amplifier quiescent current

I wish to comment about the setting of quiescent current (Iq) in audio amplifiers. I never set it up by the book – ie, adjust the trimpot for XmA or YmV across the emitter resistors. I have found that to get it right, you connect a dummy load to the output of the amplifier, connect your CRO across the load, connect your signal generator to the amplifier input and set it to say 30kHz.

With an output of full screen on the CRO with the attenuator set to 0.5V/DIV, probes on X1 setting (a total of about 4V p-p), you then adjust the Iq pot for no crossover distortion. With amplifiers that I know will run OK with more Iq, I give them say, an extra 10-15mA – it depends on the heatsink size and thermal feedback arrangements. Leaving them to soak for an hour or so and then giving them a power/cool down test usually lets you know if it's set too high.

Many years ago, a Leak Delta 70 came across my bench. When repaired, set up as above and returned to its owner, I received a phone call from him. "Oh-oh what's wrong?" was my initial reaction. As it turned out there was nothing wrong. He rang to say that he had had the unit repaired before and when he received it this time it "sounded" so much better. He had not really been happy with the sound since new but he was really pleased this time.

Brad Sheargold,
Collaroy, NSW.

Comment: we are not keen on your method for setting Iq. In our experience, at 30kHz, secondary crossover distortion becomes quite significant and usually is not greatly affected by the amount of quiescent current. In any case, trying to judge crossover distortion just by looking at a sinewave is very difficult.

Most good amplifiers will show no visible crossover distortion, even at high frequencies and low power. The only sure way to judge the setting is with the benefit of a harmonic distortion analyser which can display the distortion products on an oscilloscope.

That is not to say that some amplifiers might not benefit from a small increase in quiescent current. However we would not recommend increasing the quiescent current setting for any of our designs, unless the builder has access to the above test equipment.

Positive feedback on audio projects

This is just some feedback about very positive results I have had from several SILICON CHIP projects. The first is the 175W power amplifier (SILICON CHIP, April 1996) built for my brother who is a musician. I matched it to a version of the JC-80 loudspeakers (October 2003). I used the same drivers and crossover but changed the shape (not the volume) of the speaker box.

In the setup, a balanced microphone signal is fed into a preamp, (SILICON CHIP, April 1995) and then fed to the amplifier via a 5-Band Graphics Equaliser, (SILICON CHIP, December 1995). The results are very pleasing, with plenty of power and excellent quality sound.

The other success is a Sub Bass Processor described in "Electronics Australia" (September 1999), feeding into an SC480 amplifier (SILICON CHIP, January & February 2003), driving the subwoofer described in March 2003. The Sub Bass Processor is connected to the speaker output lines of a Pioneer stereo hifi amplifier (about 30W RMS per channel). The results were very pleasing indeed, especially playing older tapes and LPs that could only supply a rather poor bass signal.

Joe Kelly, via email.

Ratting old headlamp globes

Thanks for that great Salvage It! article on pages 90 & 91 of the February 2005 issue. Headlight globes usually fail when the low-beam filament blows before the high-beam filament. This leaves us with a globe that can't be used in a vehicle.

In the circuit on page 91, a resistor is used to limit the current to the maximum of the plugpack. By replacing the resistor with the high-beam filament of an old headlamp globe, we can utilise a globe that would normally be thrown out.

Not only does this recycle an old globe but it also acts as a constant current source, while still allowing the battery voltage to rise with time.

Let us assume that a high-beam filament is rated at 100W. Using the formula R = V x V divided by P, then the resistance of the hot filament would be about 1.44Ω. Assuming a 13.5V DC plugpack and that the battery is at about 11V when flat, there would only be a maximum of 2.5V across the globe, so it would never get hot.

The resistance of a headlight filament varies with current, thus acting as a constant current source while still charging the battery. In the case where a headlight globe was passing too much current, an 18W stoplight globe could be used.

Chris Potter, Kilsyth, Vic.

Cheap checker for remote controls

Using the Remote Control Checker kit (January 2005) or a video camera (February 2005) to check if your remote control is working are both effective. If you can't afford the above methods, try my (poor man's) version: grab the nearest broadcast trannie, tune between stations, increase volume and place the remote control within a couple of centimetres of the end of its ferrite rod antenna and press a button.

Norman Ratcliffe,
Toorbul, Qld.

Comment: your method using an AM broadcast radio works extremely well. Thanks.

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You have the choice of a rear-view "mirror" display, as shown here, or you could add a GPS unit and an old laptop computer for a highly useful "Sat Nav" unit. Both are perfectly legal to use while driving along but you cannot mount the screen in this position for "entertainment" video – for that, the driver must not be able to view the screen while driving.

By Gary Rollans

-Car Video!

THE BASIC installation we are going to describe here is a really useful rear-view video system that takes the guesswork out of reversing 4WDs, vans, trucks and buses, etc. We'll even show you how to extend it to cover caravans, large trailers and even semi-trailers, B-doubles and road trains!

Where you take it from there depends entirely on your requirements: keeping the kids entertained on long trips with games or a mobile DVD player, finding your way around Australia (or a strange city!) with GPS sat nav . . . it really is an open-ended equation.

But back to the basic system: a dash-mounted video screen and a rear-of-vehicle mounted colour video camera which gives you a much better view behind your vehicle than you can achieve with mirrors.

The camera is designed for exactly this purpose, producing a reversed output so that picture you see on the screen is just like the one you see in an ordinary rear-view mirror – ie, reversed. However, if you already have a standard camera (ie, right-reading), it's possible to use that as well. We'll explain how shortly.

The screen type

There are currently three types of screen available from Jaycar: ceiling mounted, in-dash mounted and on-dash mounted.

The hardest thing about installing one of these is choosing which one you want to use. Each has its own merits but for simplicity, we chose the QM-3753 in-dash model. This compact unit will slip into a standard DIN dashboard slot and can be folded away when not in use to minimise attention from prying eyes.

That's pretty important these days,

Mounted in the dash, the video display doesn't stand out as anything special . . .

But press the button (left top) and it pops out, ready to be . . .

. . . tilted vertical and twisted left or right for the right viewing angle.

as "obvious" in-car video screens can be tempting items for thieves. Apart from losing the screen, there's all the damage created as they break in.

We mentioned the reversed image before. Most screens, this one included, can reverse the image if required (it's most disconcerting looking at a "right reading" image behind you!). If you are using a standard (right-reading) camera, this particular monitor can reverse the image by connecting one wire. But it's more convenient to use a wrong-reading camera and a right-reading screen, because you can then use it "as is" for GPS/Sat Nav, entertainment, etc.

Screen installation

To install the screen, you will first need to remove the dashboard console panels to gain access to the CD-radio cradle assembly. On some vehicles, this is not as easy as it sounds because hidden screws may be used, air/heater/air conditioner control knobs are often difficult to remove without damage, etc, etc.

We're not going to try to advise you here – there are simply too many variables. If in doubt, try to get the workshop manual for your car or perhaps ask for advice from a car repairer or auto electrician.

Next, remove the assembly retaining screws. Most systems use some form of cradle – it should slide forward, enabling you to unplug the power and speaker connections and remove the assembly from the console. Before taking the assembly to your workspace, check the wires as you take them off. In some vehicles, they will be tagged, telling you what is what. But if they're not, tag the wires as you take them off so that they can be put back in the correct places.

Next, you will need to mount the video screen into the spare DIN mounting space of the cradle. This will vary from vehicle to vehicle so again we won't go into detail here.

It would be a good idea at this point to extend the video input connection. Jaycar have a cable (Cat. WV7316) specifically made for the task. This will let you easily connect to the screen once the CD and screen assembly is fitted back into the car. It might also be helpful to wrap a turn or two of insulation tape around the A/V connections while the assembly is out of the car. The tape will help prevent the connectors from being pulled out later when you are scratching around under the dash.

Before reinstalling the CD player and video assembly back into the dash, you will need to provide a power line for the screen and camera. This is best achieved by splicing into the CD player's power line using crimp connectors, rather than cutting and soldering, which makes later removal difficult. This splice should be made on the CD-player side of the fuse. If you choose to run a separate power line for the screen and camera, don't forget to include an in-line fuse.

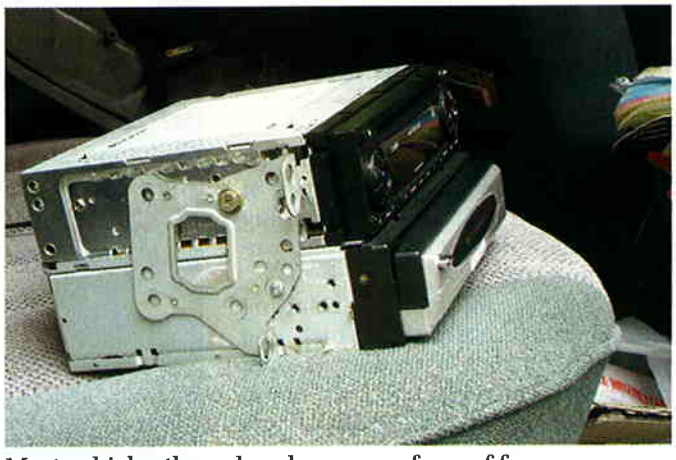
Once the power lines are in place, you can re-install the CD/video cradle assembly back into the dashboard, plug their associated connectors back in and replace the console panels. The video input leads to the screen should be positioned where they will be easily accessible when you are ready to connect the camera cable from the back of the car.

Checking the unit

Before going any further, plug the video camera into the

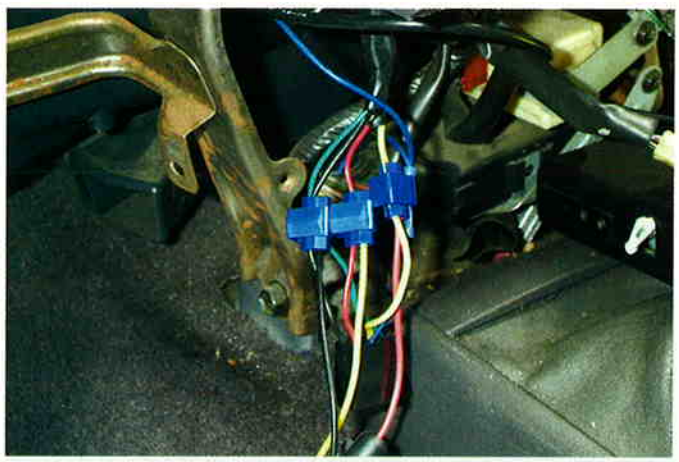
You're going to need a spare DIN space in your dashboard (the black panel underneath the radio/CD in this picture hides the space). Virtually all car stereo systems these days are made to standard DIN dimensions.

First step: uscrew/unclip the trim/fascia and carefully remove it, then disconnect the car radio/CD/cassette. Most have one or two plugs which disconnect everything. Don't forget the antenna!



Most vehicles these days have some form of frame or carrier which itself can be unscrewed and removed (makes life a lot easier!). Remove the faceplate covering the empty DIN space and slide the video screen into position in the cradle. Fasten the appropriate screws in place.

Replace the cradle in the dashboard and screw it back into position. Temporarily push the trim/fascia over the radio/CD/cassette to make sure it still fits, then reconnect all radio cables (don't forget the antenna!).



Work out which of the radio/CD/cassette cables are +12V and ground and splice the video power cables into the appropriate ones AFTER the fuse(s). It may be that there is no ground wire as such because the radio grounds via the frame. If so, you'll need to connect the video ground cable also to a good ground.

Sometimes, it's necessary to run new power cables if the radio cables are inaccessible or they won't handle the extra current. If so, it's usually best to go back to the battery and fasten a suitable fuse/terminal block (such as this Jaycar model) to the firewall.

How do you know if it's legal?

The following is an extract from the Australian Road Rules, which apply in all states. We believe NZ rules are the same or similar. Specifically, this is:

Part 18, Section 299 – Television receivers and visual display units in motor vehicles

(1) A driver must not drive a motor vehicle that has a television receiver or visual display unit in or on the vehicle operating while the vehicle is moving, or is stationary but not parked, if any part of the image on the screen:

(a) is visible to the driver from the normal driving position; or

(b) is likely to distract another driver.

Offence provision.
Note: Motor vehicle and park are defined in the dictionary, and vehicle is defined in rule 15.

(2) This rule does not apply to the driver if:

(a) the driver is driving a bus and the visual display unit is, or displays, a destination sign or other bus sign; or

(b) the visual display unit is, or is part of, a driver's aid; or

(c) the driver or vehicle is exempt from this rule under another law of this jurisdiction.

Examples of driver's aids

1 Closed-circuit television security cameras.
2 Dispatch systems.
3 Navigational or intelligent highway & vehicle system equipment.
4 Rear-view screens.
5 Ticket-issuing machines.
6 Vehicle monitoring devices.

The ***blue italics*** emphasis is ours, to highlight the uses which *are* permitted, in moving vehicles in view of the driver. Needless to say, anything which is NOT mentioned – eg, DVDs, video games, TV, etc – is prohibited.

Our advice is that it is possible you could be fined or your vehicle defected if you have a screen which is capable of displaying prohibited images while mobile, even if it is also used for driver's aids.

Therefore, if the display is fitted where the driver can view it, we would suggest a lockout system be used on the device (eg, a relay powered from the ignition switch) to prevent prohibited inputs when the ignition switch is turned on.

display video input, power up and check that all is OK. Better to find any problems now than later on when all the wiring is in place!

Installing the camera

This is a fairly simple task with the hardest part deciding where and how you wish to mount it. Some prefer to have the camera mounted inside, viewing through the back window, to give a "high" image. The alternative position is mounted inside your rear bumper – adjustable collars are actually supplied with the Jaycar QC-3452 camera for this purpose.

If you decide to fit the camera inside the vehicle, you will need to find a suitable mounting position which not only gives a clear view but minimises the danger of the camera being damaged by anything moving around the back of the vehicle. You may also need to make a small "L" bracket to mount the camera or you can do as we did and mount the camera inside a Jaycar HB-6080 flanged jiffy box and use double-sided foam pads to stick the box to the roof lining at the rear of the vehicle. That way, there are no holes to drill and no damage when it comes to disposing of the vehicle,

The hardest part about the bumper-mounted camera is drilling the 25mm hole in your rear bumper. It's easy if you have plastic bumper bars; not so easy if they are steel!

You will need a 25mm hole-saw to do the job. Once the hole has been cut and de-burred, you can fit the camera into the bumper and adjust its mounting angle using the collars supplied for the purpose. The rear of the camera has two orientation marks to help get the picture the right way up.

To get the video signal to the front of the car and power back to the camera, you will need to run a pair of cables through the cabin. These should be tucked away under the carpets, out of sight and harm's way. You can either make your own video cable or use a ready-made one, such as the Jaycar WQ-7224. Ready-made is the quickest and easiest option – and probably the cheapest as well.

One alternative for power is to use the parking light circuit. Admittedly, this means you'll need to have your parkers on whenever the system is in use but that's no big deal these days – and it might make your vehicle just that much more visible.

Getting the cables to the outside of the car can usually be achieved by routing them through one of the access bungs in the floor of the rear cargo area in a 4WD or the boot in a sedan. Typically, these are in the lowest areas such as under the spare tyre. Alternatively, you could use the same access bung which encases the cables to the number plate lamps or trailer plug.

Once the cable has been run, you can connect the power and video lines. Turn on the ignition and check that power is available at the camera. If all is OK, turn the ignition back off and plug the cables into the camera.

Now you can unfold the screen turn it on and turn your ignition on. If you have wired up everything correctly, you should have a nice rear-view picture on the screen.

Road testing

As soon as our newest toy was installed, we were eager to get out and see how it performed on the road. The first thing we noticed was the significantly better view of the

The Jaycar QC-3452 Reversing Camera is especially made for our application, providing the "mirror image" picture you're used to seeing in the rear view mirror. It is also very easy to mount – just one 25mm hole is required. The red lead is 12V CD power, while yellow is video out.

Here's the camera mounted in a Jaycar HB-6080 jiffy box (a nice, neat fit!), itself mounted on the roof of the 4WD. Different vehicles will have different mounting arrangements. An alternative is to mount the camera low down, even through the bumper bar (it is waterproof!) for an excellent reverse parking indicator.

Another view of the mounting arrangement for the camera. This gives an excellent "high up" view through the rear window when the rear door is closed. The cable can be routed above the headlining and down one of the pillars for a nice, neat installation.

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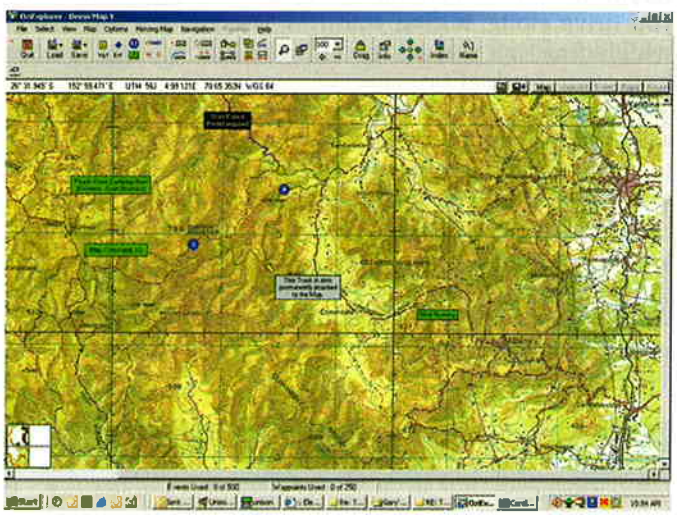
The "low down" camera position, inside the rear bumper, makes parking a breeze! Fortunately, this bumper is plastic – drilling metal is much more difficult. The angle can be adjusted via the use of supplied collars. Cabling can go via the rear number plate wiring "boot" or a cargo area drainage plug.

It's not hard to see why they're called a GPS "Mouse" but there is no mouse function at all. Inside the waterproof case, here magnetically mounted on the vehicle roof, is a GPS antenna and receiver – this particular one is a USB device but there are PC card, CF, serial and Bluetooth varieties.



Here's a demo screen from one of the freeware packages we found on the 'net. There are others which offer street-level resolution but generally you have to pay for the better ones. You don't need too much in the way of computer grunt to run them – a good use for that old laptop, maybe?

area behind the vehicle. The camera's wide-angle lens provides a 92° field-of-view and practically eliminated the blind spots in the rear quarters.

The system also provided an easy means of judging the distance to objects behind the vehicle.

We had decided to mount our camera on the ceiling at the top of the rear window, in a mid-size 4WD. From this position, we were able to see the roadway as close as one metre behind the vehicle. If mounted at bumper level, the view would be much closer.

Four-wheel-drives have great forward visibility but it's difficult to judge just how close you are to objects at the back. With our new system we were able to reverse into tight parking spaces with ease and there was no doubt how close objects were. The screen was easy to see, even in full sun and needs no skill to operate.

Other options

There are a host of useful possibilities that can be added once the basic system is installed. These include a TV tuner or a DVD player for passenger entertainment, or even a low-cost GPS navigation system utilising an obsolete notebook computer, low-cost GPS module and shareware mapping software.

You could even extend the reversing camera to a caravan by using a standard audio/video sender. If you have ever tried to reverse a caravan down a narrow driveway, you'll know how useful that can be!

Note, however, that Australian road rules prohibit any "entertainment" type video – that is from a TV tuner, DVD, game, etc, being displayed while the vehicle is in motion if the driver can view the screen.

Common sense suggests this anyway – you can imagine just how dangerous it would be trying to watch a TV screen and driving at the same time! It wouldn't be too hard to knock up some form of interlock which prevents the wrong video being displayed while the ignition is turned on.

Power supply preparation

If you are going to install more than one extra device in your system, it's probably a good idea to have extra power readily available. The best way to do this is run heavy-duty cables directly from the battery – fitting a good quality distribution block such as the Jaycar HC-4020 and a suitable automotive relay (such as the Jaycar SY-4068) and matching base (SY-4069) in the engine bay is the best way to achieve this.

First, mount the terminal block and power relay in an easily accessible place with metal screws and lock washers. Then run a length of heavy gauge cable from the terminal block via the relay and in-line fuse to the positive battery terminal. Make sure you allow enough extra cable to neatly secure the wire to the existing cable loom in the engine bay.

The cable should be terminated with a suitable connector and already connected to the terminal block before it is connected to the battery terminal. This will prevent any accidental short circuits when you are running the cable.

Power to the relay should come from the accessory side of the ignition so that the auxiliary systems only operate when the car is running or the key is in the accessory position. This is easily obtained by tapping into the supply line to the existing CD player or even the cigarette lighter

Parts List: Reversing Video

In-dash TFT monitor (QM-3753)
Reversing camera (QC-3452)
Camera power connector (PP-0510)
Crimp connectors (WV-7316)
Video extension cable (WQ-7224)
6m length of Fig-8 cable (WB-1710)
Hook-up wire, cable ties, heatshrink tubing, etc

For higher capacity supply:
Distribution block (HC-4020)
Horn relay (SY-4068)
Relay base (SY-4069)
In-line 60A fuse (SZ-2065)
Hook-up wire, cable ties, heatshrink tubing, etc

Note: all part numbers refer to catalog numbers for Jaycar Electronics.

socket, which is normally switched on by the ignition switch in most cars. When this is complete you will have a convenient point to run the power lines to from the extra equipment.

Adding GPS navigation

Now that you have a video screen installed in your car, there are lots of other applications. One of the easiest is an in-car GPS navigation system. Commercial units cost $1500 or more but you can cobble one together for just a few hundred dollars using a notebook computer, a "mouse" GPS receiver and free software readily available from the Internet.

There are plenty of older laptops lurking around and they don't need to be very powerful to do the job. The system described here runs on a Toshiba 600MHz Celeron but the development was done on an old Pentium 100 with 16Mb of RAM!

The only reason we ended up using the Toshiba was because it has on-board composite video out, so was a bit easier to interface to the screen (ie, it plugged straight in!). But even the old P-100 worked fine with the addition of a VGA to composite converter – these are readily available from Jaycar Electronics and cost around $100.

There are many ways to put this system together and once you have started to poke around the Internet, you will doubtless find a few more.

The GPS receiver

While this system will work with the majority of GPS receivers that have a data (computer) output, our system utilises a low cost "mouse" GPS receiver that we bought brand new on Ebay for about $110.

In fact, we bought this about a year ago and it's been sitting around waiting for a use such as this. Currently on Ebay, the same devices are selling for about $75.00 – you might even do better! There's no screen, buttons, switches, or anything else that the dearer, self-contained GPS units have but it is perfectly suited to our task.

The device consists of a matchbox-sized module with a USB (or serial) connector on the end of two metres of cable. It is waterproof and has a strong magnetic base to secure it to the roof of the vehicle. The unit could easily be left on the dashboard (for better security) but the roof mounting gives the receiver a better view of the sky (ie, more satellites to view) and therefore better accuracy.

Be careful when buying a GPS receiver that you get one that is NMEA-compatible. Most are but for some unbelievable reason, a few recent models have gone their own way and use their own non-compatible software. If you want to use the GPS with mapping software, for example, it will almost certainly need to output using NMEA code.

Also be careful about the interface between the GPS receiver and the computer. As mentioned above, most are USB or RS-232C serial and so plug straight into most laptops. Some are PC-slot (once called PCMCIA) compatible and most laptops and notebooks, even low cost and relatively elderly ones, have at least one PC slot.

There are some otherwise fine GPS receivers available which are ONLY CF-slot compatible. These plug into a compact flash card (CF) slot on a PC but until fairly recently, few laptops had one of these built in. Fortunately, CF-to-USB adaptors are very commonly available and are also cheap (for example, $10 on EBAY will get you a multi-card adaptor). You can also get cheap CF to PC-slot adaptors.

Installation

What installation? It could hardly be easier. Simply plonk the GPS receiver on the vehicle roof, plug it into the notebook, plug the composite video output from the notebook into the monitor and load the software. OK, so you might need to add a VGA-to-composite video converter if your laptop doesn't sport composite video out but that's it.

Software

GPS software is readily available on the Internet and we have tried three different versions. Two are freeware and one has to be paid for.

Two of them follow the normal Windows style with tool bars at the top of the screen and the selected map below. The third version operates under Windows but has a full screen display. It also has a number of interesting features including a speech option that gives you a commentary as you drive along, telling you how fast you are travelling, which direction you are travelling in and how far you are from your destination.

The program can also be used with voice recognition software to produce a voice-driven system that talks back to you. None of these have turn-by-turn directions but this will undoubtedly be available before too long.

In fact, there's probably freeware or shareware out there which does it already – it's just a matter of searching.

All three programs we looked at allow you to scan your own paper maps and calibrate them for use with the system You can also download digital maps from the Internet for free. **SC**

Where To Get Software

www.oziexplorer.com – this costs around $110 and is locally written.
www.gpss.co.uk – this site is free and has all the speech stuff.
www.gpstm.com – this Brazilian site is also free (in English).

Atlas SCR Thyristor & Triac Analyser

This latest in-your-palm tester from Peak will reliably check all thyristors and Triacs that you are likely to encounter. Just connect the mini-hook leads (in any order) and press "test"!

You might be surprised to learn that hand-held semiconductors testers often do not have the capability to accurately test "sensitive gate" thyristors and Triacs. Typically, these instruments provide only one gate current level regardless of device. Although a higher than specified current would fire a sensitive gate device, there's no guarantee that it will operate normally when in circuit.

Paradoxically, many testers do not provide high enough gate current to reliably trigger some larger devices. The test current used (anode to cathode or MT1 to MT2) may also be too low, particularly as the instrument's battery voltage declines.

Reliable testing

Peak has addressed these issues and eliminated the guesswork with the Atlas SCR. Devices are tested with up to eight discrete gate current levels (100µA, 500µA, 2.5mA, 10mA, 25mA, 50mA, 75mA & 90mA). Naturally, testing starts at the lowest level and progress towards the higher levels, ensuring that the minimum necessary trigger current is used.

Note: Triacs are tested in both quadrants 1 and 3 but only the gate current for quadrant 1 is displayed.

To ensure consistent results, test current is fixed at 100mA (nominal) regardless of battery condition and is applied as 100µs pulses. This eliminates the possibility of damage to sensitive devices.

Rocket science?

The Atlas SCR works the way all test instruments should (we think). Just connect the three mini-hook leads in any order and press "test". The tester then automatically determines device type and pin-out and displays the results on its 16-character x 2-line LCD.

The device type (thyristor or Triac) is displayed first up. Alternatively, if the device has an internal short or open circuit or fails to trigger, an appropriate message is displayed instead.

Three more informative screens are accessible by pressing the "scroll" button. The first of these displays the pin-out details. Another press brings up the trigger current, with a third displaying the test current. As this value is fixed at 100mA, it serves only as a reminder.

After a short delay, the instrument switches itself off or you can press and hold the "scroll" button to save even more battery power.

There's little more to tell you about this useful little device. If you're in market for a hand-held "go/no-go" thyristor and Triac tester, you won't find a better deal anywhere!

Where to get yours

As well as the Atlas SCR Thyristor and Triac Analyser, Peak offers a number of other useful test instruments in the same handy form-factor – eg, the Atlas LCR Passive Component Analyser (see Circuit Notebook).

Peak Electronic Design is situated in Derbyshire, UK. You can purchase their products on-line at this site: **www.peakelec.co.uk**. Current price for the Atlas SCR including airmail delivery is $227.20, subject to exchange rate variations.

Their products are also available locally through Farnell, although the Atlas SCR is not currently listed. See **www.farnellinone.com.au** or phone 1300 361 005 for availability. **SC**

Main Features

- Automatic identification of component type (thyristor or Triac)
- Automatic lead identification (just connect any way around!)
- Categorisation of gate sensitivity (100µA, 500µA, 2.5mA, 10mA, 50mA, 75mA or 90mA)
- Load test conditions of 12V @ 100mA (regardless of battery condition)
- Test pulse durations less than 200µs minimises possibility of damage
- Fault identification (shorted junctions, faulty operation)
- Clear and user-friendly scrollable display
- Supplied with detachable micro-hook probes

The Inside Story On UPS

- UPS is short for Uninterruptible Power Supply.
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- Protects your equipment against not only power surges and spikes (where there is excess voltage) but also against sags (where there is insufficient voltage).

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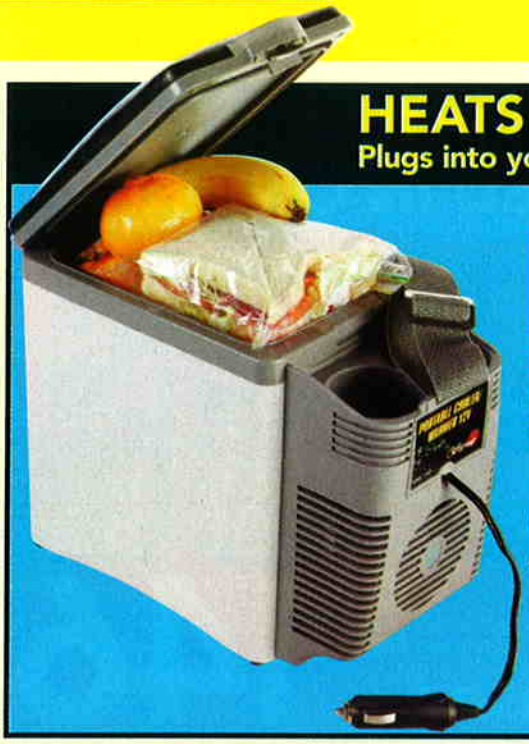

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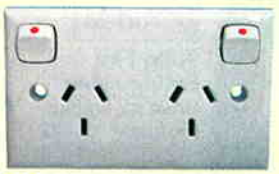

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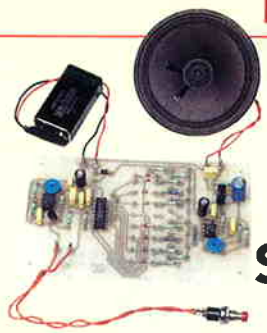

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MIDI THERE

Move over "Theremin" . . . the "MIDI Theremin" is here. While it's based on the original concept of producing sounds using hand movement, it has now gone digital, taking the Theremin from the 20th to the 21st century!

The original Theremin, with a foot pedal to control volume and a switch mechanism to control pitch, was invented during World War One – in 1917, to be exact – in St Petersburg, Russia.

It was named after its inventor, a young cellist and physics student, Lev Sergeivitch Termen. (It was also known as the Aetherophone or Etherphone, meaning "sound from the ether").

Termen's life story is a kaleidoscope of intrigue itself. After demonstrating and playing his device throughout Russia and Europe (Lenin was said to have been very impressed), he travelled to the USA in 1927 and decided to stay, and married . . . much later, it was claimed he was in the US as a Russian spy.

Lev Termen "playing" the RCA Theremin, first produced in 1929.

But in 1938 he was kidnapped by the Russian NKVD (which later became the KGB) and clandestinely spirited back to Russia, where he was sentenced to a Siberian labour camp for "anti-Soviet propaganda".

After his "rehabilitation", he apparently again found favour with Russian authorities and taught at the Moscow Music Conservatory up until his death in 1993, aged 97.

In his later years he was again allowed to travel to the USA where he was introduced to the Beach Boys, who themselves made the Theremin famous in one of the most famous tracks of all time – Good Vibrations.

We've immortalised Lev to some degree (who incidentally was known

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Features

- Sound output via a computer and speakers or a synthesiser
- Selection of 15 instrument types with 8 variations of each
- Record, save and playback using a computer
- Volume plate and pitch antenna
- Auxiliary input for pitch or note change
- Back-lit LCD shows instrument selection, volume, note and pitch or settings
- Selection of sustain on or off
- Adjustment for discrete note or pitch glide effect between notes
- Selection of normal or wide note range
- Selection of notes with or without sharps
- Selection of antenna operation from note change to pitch change and auxiliary input from pitch glide to note change
- Midi out, games port or serial connections (USB via a converter)
- Plug-pack powered

MIDI THEREMIN

Part 1:
by John Clarke

This close-up of the completed MIDI Theremin shows the various controls on the front panel (fully explained in the text), along with the volume level plate (left) and the telescoped whip antenna (top), here shown in the "transport" position.

in the west under the Gallic form of his name, Léon Théremin) by including a stylised image of him on the front panel of our design!

The Theremin version we know today, using a volume plate and pitch antenna, was developed and first produced in 1920. A commercial Theremin was built by RCA in 1929 and comprised a large wooden box to house the valve electronics and included the volume plate (actually a wire loop) and pitch antenna.

Moving the left hand closer to the sensor would reduce the volume level; conversely, taking the hand away would increase the level. Similarly, pitch could be controlled using hand movement around the antenna. The thinness of the antenna allowed for very fine pitch adjustment by only moving the fingers while keeping the hand still. Larger pitch changes could be accomplished by moving the hand inward to decrease the pitch and away from the antenna to increase the pitch.

Somewhat unsuccessfully marketed as a replacement for a piano, RCA's Theremin sold for $US175 in 1929. Oh, you wanted tubes (valves) and a loudspeaker with that? Another $71.50, please! (That was, of course, a *lot* of money in 1929).

The sound produced by that Theremin (or by modern versions) is similar to the eerie sounds heard in many science fiction movies. In fact, it *is* the eerie sound heard in many science fiction movies!

Although some may consider the Theremin to be just an electronic toy, it's also regarded by others as a legitimate musical instrument. There have been countless professional performances using the Theremin , either alone or as part of an orchestra.

From Theremin to synthesiser

The Theremin concept lead to the development of electronic music, starting with the Moog (pronounced mogue, as in vogue) synthesiser (invented by Robert Moog in the 1960s). Today we have fully digital synthesisers and samplers that can produce just about any type of sound imaginable.

Incidentally, any idea where Robert Moog got his interest in electronic music from? You guessed it, a home-made Theremin he built from a magazine article when he was 14 years old.

The Theremin itself has also been updated in many forms over the past 80+ years to use transistors in the electronics instead of bulky and

What is MIDI?

MIDI is an acronym for **M**usical **I**nstrument **D**igital **I**nterface. It is a system for communicating between synthesiser-equipped electronic musical instruments and PC-based sequencers.

The communication is a series of codes that can control the synthesiser. **Control codes** can for example be sent to set the instrument sound, start or stop a note being played, vary the pitch of the note and set the volume. The code is sent as 10-bits with one start bit, eight code bits and a stop bit at a rate of 31.25k baud. The communication is asynchronous and is provided using a 5mA current loop.

In more detail, a MIDI message can be defined as either a **channel** or **system message**. The **channel message** applies to a specific synthesiser channel from 1 to 16, while the **system message** applies to all channels.

System messages include resetting, tuning and timing codes.

Channel messages can be further broken down into ***voice*** or ***mode messages***. The ***voice messages*** include turning a note on or off, the pressure (how hard a key on a keyboard is pressed), pitch blend (where the note frequency changes off key) and program change (to alter instrument).

Mode messages affect the way the synthesiser will respond to a note being played.

For example, the sustain effect can be switched on or off and the note can be selected to pan between the left, centre or right channels

power-hungry valves.

Later designs used both transistors and then ICs – a design using ICs was published in the August 2000 issue of SILICON CHIP (the article is available via www.siliconchip.com.au).

That design replicated the original Theremin in the way it produced sounds, using the pitch antenna and volume plate approach. The project remains very popular to this day, with Jaycar Electronics and Dick Smith Electronics still selling it as a kit.

Although the August 2000 Theremin works well, it is only able to produce the original, characteristic Theremin sound – an almost pure sine wave, which is *not* overly musical.

We reasoned that the Theremin would be more interesting to play and use if it could produce different sounds. So why not merge the old and the new and use a digital synthesiser to produce the sounds while keeping the original Theremin control format with the pitch antenna and volume plate?

And that is exactly what we have done – produced a MIDI Theremin that has the volume plate and the antenna for volume adjustment and pitch control as in the original Theremin – but instead of providing an internal sinewave oscillator to produce the basic sound, we control an external synthesiser instead.

Use of the synthesiser allows a huge selection of different instrument sounds that can be played, all under the control of the MIDI Theremin.

And just in case you are wondering where you get a synthesiser from, it is available in just about every home in the developed world – in your personal computer.

We take advantage of a now-universal standard, the Musical Instrument Digital Interface or MIDI and the myriad of software available for MIDI on the PC. More on this shortly!

Accompany the computer with multimedia loudspeakers and you can begin to realise the possibilities of the sounds produced by the MIDI Theremin. And for even greater sound levels and deeper bass, connect the computer's audio output to an amplifier and high fidelity speakers.

In fact, if you want to reproduce the very low frequencies that can be generated via the MIDI Theremin setup, hifi speakers are a must.

The MIDI Theremin is easy to use. A liquid crystal display (LCD) screen shows what is happening. In fact, when the display is showing the volume level, note and pitch, it is possible to play the MIDI Theremin even without listening to it. Perhaps Beethoven would have appreciated the visual feedback of this unit, being totally deaf in his latter years!

Specifications

Note Range with Sharps (#) *(reference: middle C is designated as C3 (261.626Hz):*
Wide C#-2 to G8 (126 notes, over 10 octaves) (8.662Hz to 12.544kHz)
Normal C1 to C6 (61 notes, 5 octaves) (65.406Hz to 2.093kHz)

Note Range without sharps (Natural or C Major scale):
Wide D-2 to G8 (74 notes, over 10 octaves) (9.177Hz to 12.544kHz)
Normal C1 to C6 (36 notes, 5 octaves) (65.406Hz to 2.093kHz)

Pitch glide: 8 steps between notes for wide note range
16 steps between notes for normal note range
Compensation of pitch between notes when there is no sharp in between the note (i.e. between E and F and B and C)

Pitch glide range *(calibration is synthesiser dependent)*:
0 to 255 for between notes that include a sharp
0 to 511 for between notes without sharps

Pitch range when antenna is selected set for pitch variation:
-500 to +500 (not calibrated) in steps of 1

Volume steps: >1000 steps from maximum level to off

Volume display: 0 to 500 in steps of 1 *(500 is maximum volume)*

Current consumption:
135mA with 9V DC in

MIDI out: 5mA loop, galvanic isolation for games port *(31.25k baud)*

Serial out: RS232 levels *(38.4k baud)*

Sound differences

The sound produced by the MIDI Theremin and synthesiser combination is not exactly the same as the original Theremin.

While the original Theremin could produce a virtually infinite number of tones over its frequency range, a synthesiser can only play discrete notes.

This effect goes against the Theremin "continuous frequency" concept, so we have incorporated a pitch glide feature where the pitch of a note changes for in-between note positions on the antenna.

The glide feature is implemented in such a way that the change from note to note is less noticeable than without the pitch glide effect. There is still a distinct level change when another note begins but the effect is very good at simulating a continuous variation in tone.

In particular, this is true when specific instruments are selected and if the hand movements are not extremely slow. The accompanying instrument table shows the instruments that can be used to best effect with this pitch glide feature to simulate the continuous tone variation of the original Theremin. The designated instruments are marked with an asterisk.

Presentation

The MIDI Theremin is housed in a small plastic box which is mounted on a sloping stand. The stand acts to raise the hand plate and antenna above the desktop (or wherever it is placed) so that the hand controls are not affected by the proximity to the mounting surface.

The sloping face of the box also improves visibility of the LCD screen and the operation of the hand plate.

The hand plate and antenna are spaced as far apart as possible and oriented so that the left and right hands operate in different planes. This prevents any interaction between the two controls.

By the way, the antenna is normally used in its retracted, or closed, posi-

Instruments that can be selected with the MIDI Theremin

PIANO			
1.Acoustic	2.Bright Acoustic	3.Electric Grand	4.Honky Tonk
5.Electric #1	6.Electric #2	7.Harpsichord	8.Clavichord
CHROMATIC PERCUSSION			
1.Celesta	2.Glockenspiel	3.Music Box	4.Vibraphone
5.Marimba	6.Xylophone	7.Tubular Bells	8.Dulcimer
ORGAN			
1.Drawbar	2.Percussive	3.Rock	4.Church
5.Reed	6.Accordian	7.Harmonica	8.Tango Accordion
GUITAR			
1.Acoustic	2.Steel Acoustic	3.Electric Jazz	4.Electric
5.Electric Muted	6.Overdriven	7.Distortion	8.Harmonic
BASS			
1.Acoustic	2.Electric (Finger)	3.Electric (Pick)	4.Fretless
5.Slap #1	6.Slap #2	7.Synth #1	8.Synth #2
STRINGS			
1.Violin	2.Viola	3.Cello	4.Contra Bass
5.Tremolo*	6.Pizzicato	7.Harp	8.Timpani
ENSEMBLE			
1.String #1*	2.String #2*	3.Synth Strings #1*	4.Synth Strings #2*
5.Choir Aahs*	6.Voice Oohs	7.Synth Voice*	8.Orchestra Hit
BRASS			
1.Trumpet	2.Trombone	3.Tuba	4.Muted Trumpet
5.French Horn	6.Brass Section	7.Synth #1	8.Synth #2
REED			
1.Soprano Sax	2.Alto Sax	3.Tenor Sax	4.Baritone Sax
5.Oboe	6.English Horn	7.Bassoon	8.Clarinet
PIPE			
1.Piccolo	2.Flute	3.Recorder	4.Pan Flute
5.Blown Bottle	6.Shakuhachi	7.Whistle	8.Ocarina
SYNTHESISER LEAD			
1.Square	2.Sawtooth	3.Calliope	4.Chiffer
5.Charango	6.Voice	7.Fifths Sawtooth	8.Bass
SYNTHESISER PAD			
1.New Age	2.Warm	3.Polysynth	4.Choir
5.Bowed*	6.Metallic*	7.Halo*	8.Sweep*
SYNTHESISER EFFECTS			
1.Rain	2.Soundtrack	3.Crystal	4.Atmosphere
5.Brightness	6.Goblins*	7.Echoes*	8.Science Fiction*
ETHNIC			
1.Sitar	2.Banjo	3.Shamisen	4.Koto
5.Kalimba	6.Bagpipe	7.Fiddle	8.Shahnai
PERCUSSIVE			
1.Tinker Bell	2.Agogo	3.Steel Drums	4.Woodblock
5.Taiko Drum	6.Melodic Drum	7.Synth Drum	8.Reverb Cymbal

Those marked with a * produce eerie sounds characteristic of the original Theremin, particularly when the pitch glide control is set correctly.

tion. Extending it has the same effect as bringing the hand closer to the antenna.

The LCD becomes the "window" to view the MIDI Theremin's operation. It can show the selected instrument, effects settings, volume, note and pitch being played, plus other settings.

Nine pushbutton switches are used to change the instrument, the effects and other settings.

An auxiliary potentiometer control (used for different effects) is mounted on the righthand end of the box. You can make this an external control (eg, used with a foot pedal) via the stereo jack socket at the rear of the box.

Other connectors at the rear of the box are the MIDI out, the serial connector, the games port connector and the DC power socket for the 9V DC plugpack attachment. A power switch selects power and the LED adjacent to the MIDI socket is for the MIDI invalid indication. More on this later.

Synthesiser

As mentioned, the MIDI Theremin cannot be used on its own; it needs to be connected to a synthesiser. By far the most common source of a synthesiser is inside a standard personal computer or laptop using the soundcard's synthesiser.

However, as MIDI itself is a standard, another source for a synthesiser is in a MIDI electronic instrument such as a MIDI keyboard. The MIDI Theremin can be used on either of these two synthesisers.

Signals from the MIDI Theremin are sent as a series of codes in MIDI format that command the synthesiser to produce sounds.

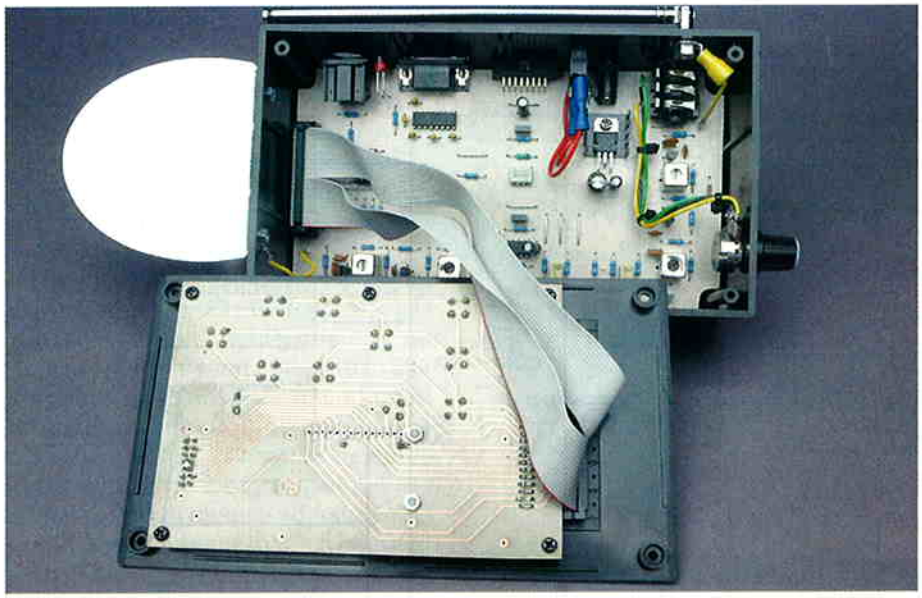
More detail on MIDI can be seen in the accompanying "What is MIDI" section.

To connect the MIDI Theremin to a MIDI instrument you use a purpose-made MIDI lead between the two.

When connecting to a computer, you have the option of using either the games port outlet (which connects directly to the computer's sound card), or to the serial outlet that connects to a serial port on the computer.

The sound card input on the computer will accept MIDI signals directly and uses a DB15 connector. Many modern computers do not have a games input and so you will need to use a serial port instead.

If you do not have a serial port or



This inside shot gives a good idea of how it all goes together. There are two PC boards, the main one mounting in the case and the display board in the lid. They're connected by an IDC cable. You'll find construction details next month.

games port, then the only way to use the MIDI Theremin is via the USB port on the computer. In this case, you will need to use a MIDI to USB converter or a serial port to USB converter.

MIDI to USB converters currently cost around $140, while serial to USB converters are only around $40, so if you need to use USB ports on the computer we recommend the serial to USB option. In both cases, software will need to be installed in order for the USB ports to respond to the signals sent by the MIDI Theremin.

Houston, we have a problem!

The signal at the MIDI Theremin's serial (computer) output is not genuine MIDI standard. It's 38.4k-baud vs MIDI's 31.25k-baud. Consequently, this can only be used to drive a computer, NOT a MIDI instrument.

In this case, a LED lights to indicate that the MIDI output is invalid.

The oscilloscope waveforms of Fig.2 show the difference.

At the top is the genuine MIDI signal with 31.25k-baud rate codes, while the lower trace shows the same code transmission at the 38.4k-baud rate suitable for the serial port computer connection. The lower trace also shows how the signal transmission is completed over a shorter time.

Software

Software is required when using the computer as the synthesiser source. The main software is the sequencer program. This accepts the MIDI signal sent by the MIDI Theremin and directs it to the sound card's synthesiser. The sequencer also provides many other functions such as the ability to record the music, store it and play it back.

You can also multi-track record for up to 32 tracks and mix these together using individual volume level settings. Panning from left to right, instrument change, looping and quantisation effects are also available. We used a freely available sequencer program that can be downloaded from the Internet.

The software works with Windows 3.1, 95, 98, Me, 2000, NT and XP. We will explain how to download, install and use the software in Part 2. Software for the serial port driver works with Windows 95, 98, Me, 2000, NT and XP.

Presumably, if you are using Windows 3.1, this serial port driver will not be required since you will have the games port available.

The serial-to-USB port driver works with Windows 98 through to XP.

MIDI Theremin controls

By far the most-used control on the MIDI Theremin will be the Instrument/Note switch. This switch selects whether the display will show the current instrument selection or the volume, note and pitch value. Each pressing of the switch will toggle the selection from one to the other.

To select an instrument, you press the Instrument/Note switch to bring up the word "INSTRUMENT" on the top line of the LCD. The second line will show the current instrument selection.

Instruments are selected using one of four switches. To change the in-

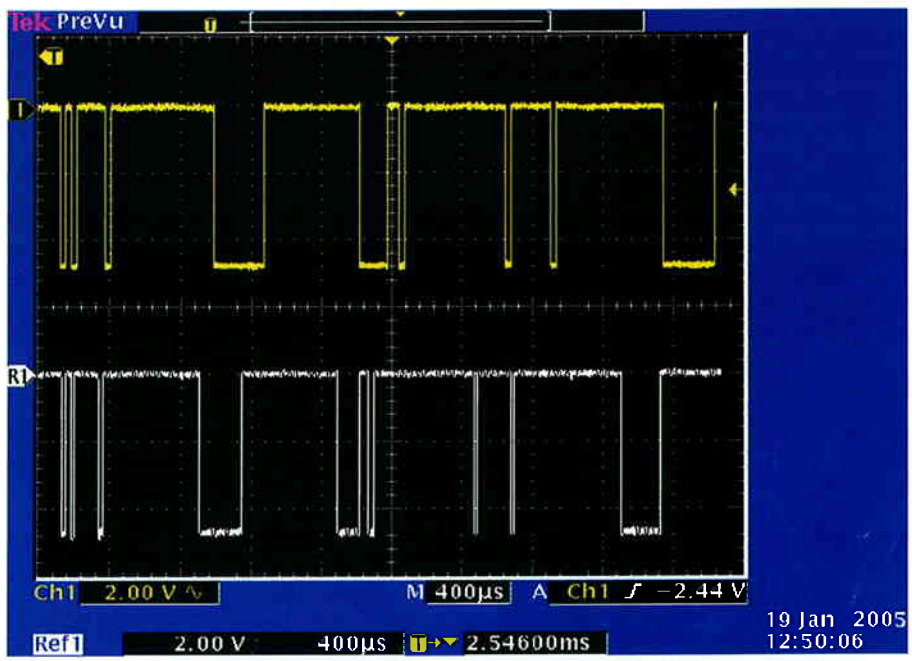


Fig.2: these oscilloscope waveforms show the difference between a genuine MIDI signal (yellow trace) operating at a 31.25k-baud rate and a serial output signal (white trace) with the same code transmission but operating at a 38.4k-baud rate. The lower trace shows that the signal transmission is completed in a considerably shorter time than for the top trace, which is why this serial output is not MIDI compatible.

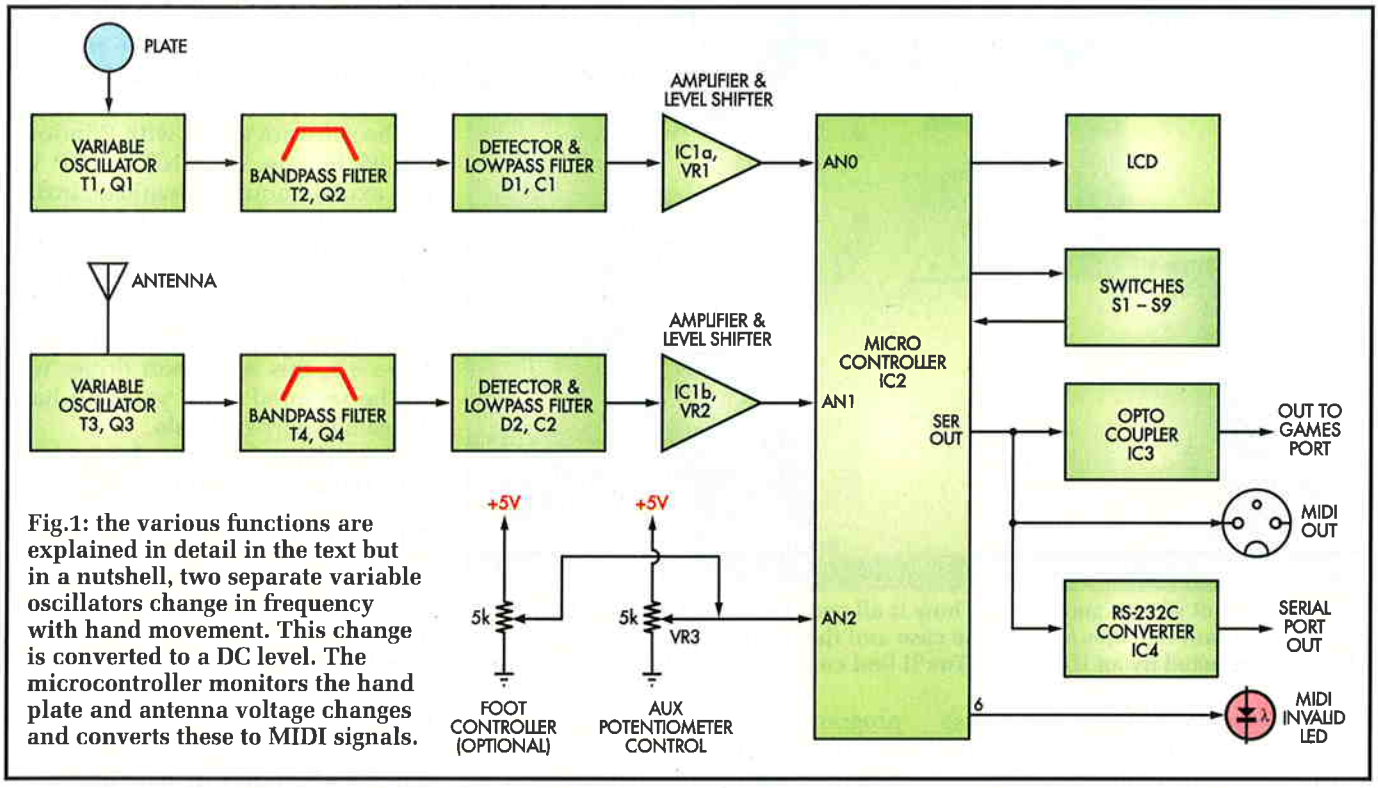


Fig.1: the various functions are explained in detail in the text but in a nutshell, two separate variable oscillators change in frequency with hand movement. This change is converted to a DC level. The microcontroller monitors the hand plate and antenna voltage changes and converts these to MIDI signals.

strument selection you can press the Instrument Up or Instrument Down switch to single step to the next instrument.

Alternatively, you can use the step up or step down switches to select one of 15 various instrument groups. The Instrument Up or Down switch can then be used to select one of the eight variations available within the selected group.

The instrument types available are Piano, Chromatic Percussion, Organ, Guitar, Bass, Strings, Ensemble, Brass, Reed, Pipe, Synthesiser Lead, Synthesiser Pad, Synthesiser Effects, Ethnic and Percussive.

The LCD will show the selected instrument with these names, although some abbreviations are used for the longer names. For example, synthesiser is abbreviated to "Synth". Within each instrument group, the eight types are labelled from #1 to #8. There is a subtle difference between some of these types, particularly the piano selections.

The full list of instruments, including the types and their numbers (from 1 to 8) that can be selected is shown in the table on page 28.

For each instrument you can select the sound to come from the left channel (shown on the display as an <L>), the centre channel (both left and right channels), shown as a <C>, from the right channel as an <R>, or off <OFF>. These are selected using the < or > switches.

The off position is useful when testing the Theremin response to the hand controls by using the LCD to show what is happening rather than listening to the synthesiser.

Note that the < and > bracketing is an indication that the labelling within these can be changed using the < or > switch. These brackets are shown where you can change other settings available on the MIDI Theremin.

The Note display is selected when the Instrument/Note switch is pressed again. The top line display shows the volume level setting, the note that is being played at the time and in which octave it is positioned.

Volume is indicated with a loudspeaker cone and sound wave icon and the volume level as a number from 0-500, with 500 representing maximum.

Notes are shown with a stylised notes icon and A to G labelling. Sharps are indicated with # to conform to musical labelling convention. The current octave being played is shown, with the lowest octave labelled as -2 through to the highest octave at number 8.

The lower line on the LCD shows the pitch or pitch glide value but more about this later.

The table opposite shows the possible notes that can be played using the MIDI Theremin. It shows the octave,

This rear-panel photo shows the telescopic whip antenna (top) and volume plate (right) but more importantly (left to right) the external foot switch jack socket, DC power socket, games port, RS-232C (serial) port with its non-MIDI warning LED and the MIDI socket.

note and frequency for each. Middle C is defined as C3.

Effects

There are several note effects available when playing the MIDI Theremin. These include the pitch glide, sustain, and note range, sharps and inputs usage.

The pitch glide controls the degree of pitch change between notes. It is adjustable from 0, when there is no pitch change between notes, up to 255 between a note and a sharp and up to 511 between standard notes.

The actual pitch change depends on the synthesiser but in general the amount of pitch change adjustment is beyond the difference in pitch between notes. This means that it is possible to set the pitch range at less than maximum so that the pitch glides smoothly between notes, making note changes less abrupt.

The pitch glide control is the auxiliary potentiometer. For knob settings between fully anticlockwise and halfway, the Note display will show the Pitch Glide as 0 – ie, no pitch glide – so the notes produced are discrete and distinct from one another. As the auxiliary control is turned further clockwise, the degree of pitch glide increases. The display shows the actual pitch being introduced as you play the Theremin.

You will see the pitch value change as you sweep between notes. Setting the pitch glide to maximum will cause the pitch to change beyond that of the next note to produce a snap-on effect as the note changes.

The sustain setting is selected by pressing the Effects switch. This brings up the word SUSTAIN on the top line and <ON> or <OFF> on the lower line. The setting is changed from on to off to on by pressing the < or > switch.

After selecting the required sustain setting, the Instrument/Note switch must be pressed before the MIDI Theremin can be played.

Note that the "Sustain On" effect can only be used with naturally decaying note instruments, such as piano, guitar, bass and percussive, as well as some strings and others. Sustain causes the note to take a longer time to decay.

Naturally note-sustaining instruments such as violin, organ, ensemble, brass, reed and effects types should not be set to include the sustain effect.

If sustain is set for these instruments, then the notes played will continue until there is a crescendo of notes and the synthesiser becomes overloaded. Pressing the Effects switch and returning sustain to off will stop this if it happens.

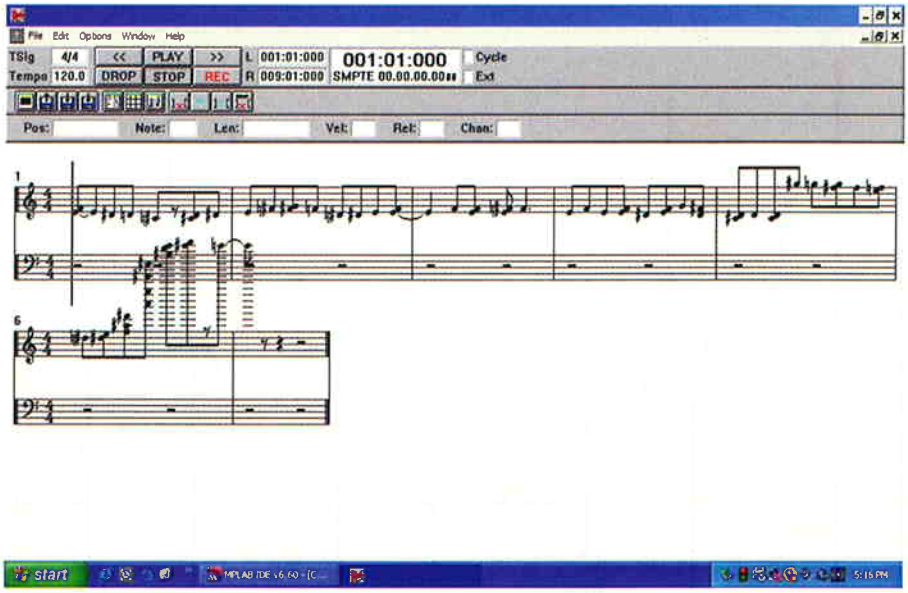
A second pressing of the Effects switch will show NOTE RANGE on the top line and <NORMAL> or <WIDE> on the lower line. You can select either of these using the < or > switches.

The normal note range extends from C1 to C6. The wide note range is from D-2 to G8 when no sharps are selected and from C#-2 to G8 when sharps are selected. The normal note range when sharps are included corresponds to a standard 61-note organ keyboard. This covers the frequency range from 65.41Hz to 2,093.0Hz and should be adequate for most playing purposes.

The wide note range is good for reproducing very wide-frequency range instruments (such as a pipe organ), as well as reproducing the high frequencies of instruments such as tubular bells.

The next selection with the Effects switch is the note effects. In this case, NOTE EFFECTS will be displayed on the top line and <INC. SHARPS> or <NO SHARPS> will be shown on the second line. You can select one of these with the < or > switches.

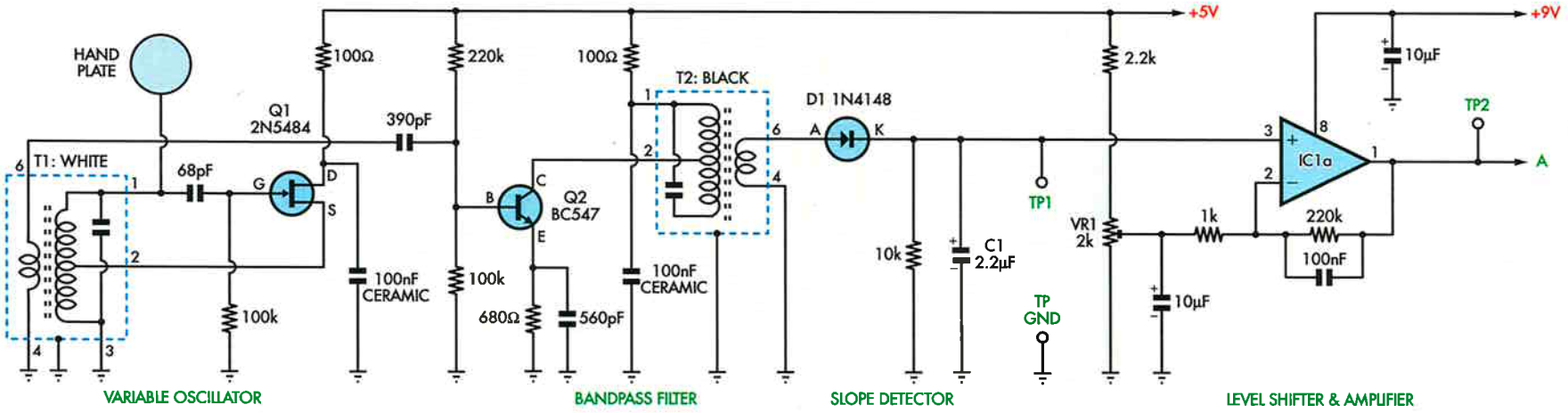
The NO SHARPS selection is some-

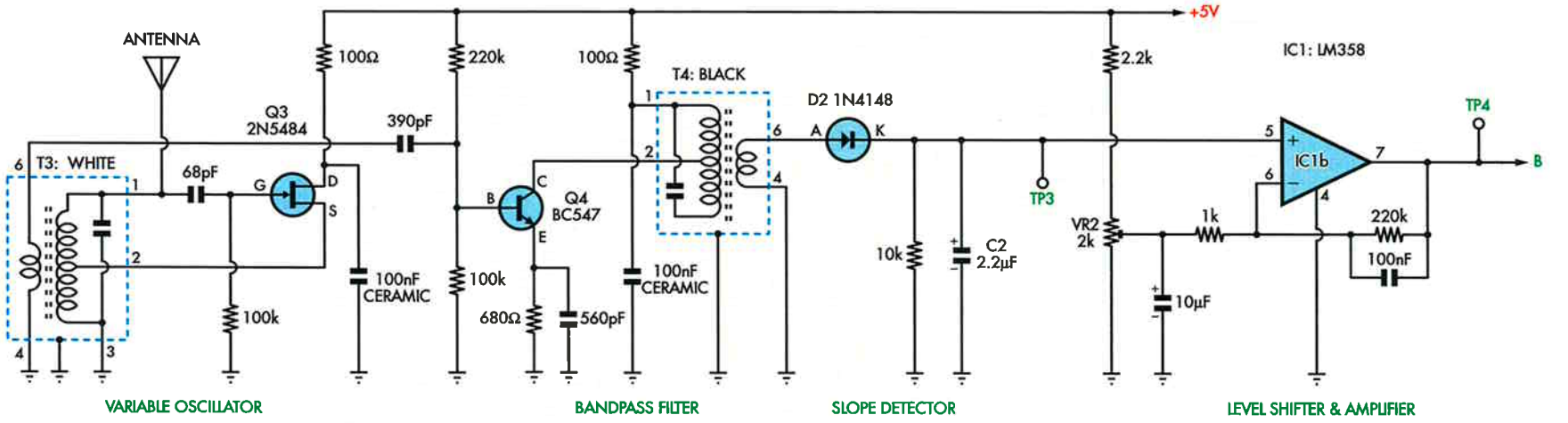


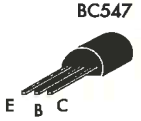
A screen grab of the software we use to drive the MIDI Theremin. The sequencer software can show the sequence of notes that were played during recording. They are displayed in the standard 5-line music format.

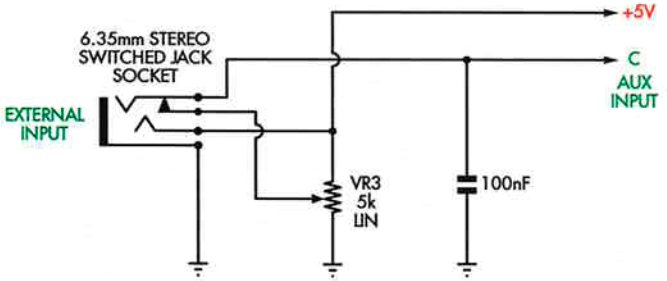
Notes available with the MIDI Theremin (frequency in Hz). Middle C is C 3. Sharps are labelled with a #.

Octave	C	C#	D	D#	E	F	F#	G	G#	A	A#	B
-2	-	8.66	9.18	9.72	10.30	10.91	11.56	12.25	12.98	13.75	14.57	15.43
-1	16.35	17.32	18.35	19.45	20.60	21.83	23.12	24.50	25.96	27.50	29.14	30.87
0	32.70	34.65	36.71	38.89	41.20	43.65	46.25	49.00	51.91	55.00	58.27	61.74
1	65.41	69.30	73.42	77.78	82.41	87.31	92.50	98.00	103.83	110.00	116.54	123.47
2	130.81	138.59	146.83	155.56	164.81	174.61	185.00	196.00	207.65	220.00	233.08	246.94
3	261.53	277.63	293.66	311.13	329.63	349.23	370.00	392.00	415.30	440.00	466.16	493.88
4	523.25	554.36	587.33	622.25	659.25	698.46	739.99	783.99	830.61	880.00	923.33	987.77
5	1,046.50	1,108.74	1,174.66	1,244.51	1,318.51	1,396.92	1,479.98	1,567.98	1,661.22	1,760.00	1,864.66	1,975.53
6	2,093.00	2,217.46	2,349.32	2,489.02	2,637.02	2,793.83	2,959.96	3,135.97	3,322.44	3,520.00	3,729.31	3,951.07
7	4,186.01	4,434.92	4,698.64	4,978.03	5,274.04	5,587.65	5,919.91	6,271.03	6,664.88	7,040.00	7,458.62	7,902.13
8	8,372.02	8.869.84	9,397.27	9,956.06	10,54808	11,175.30	11,839.82	12,543.85	-	-	-	-









MIDI THEREMIN

(ANALOG/USER INTERFACE CIRCUITRY)

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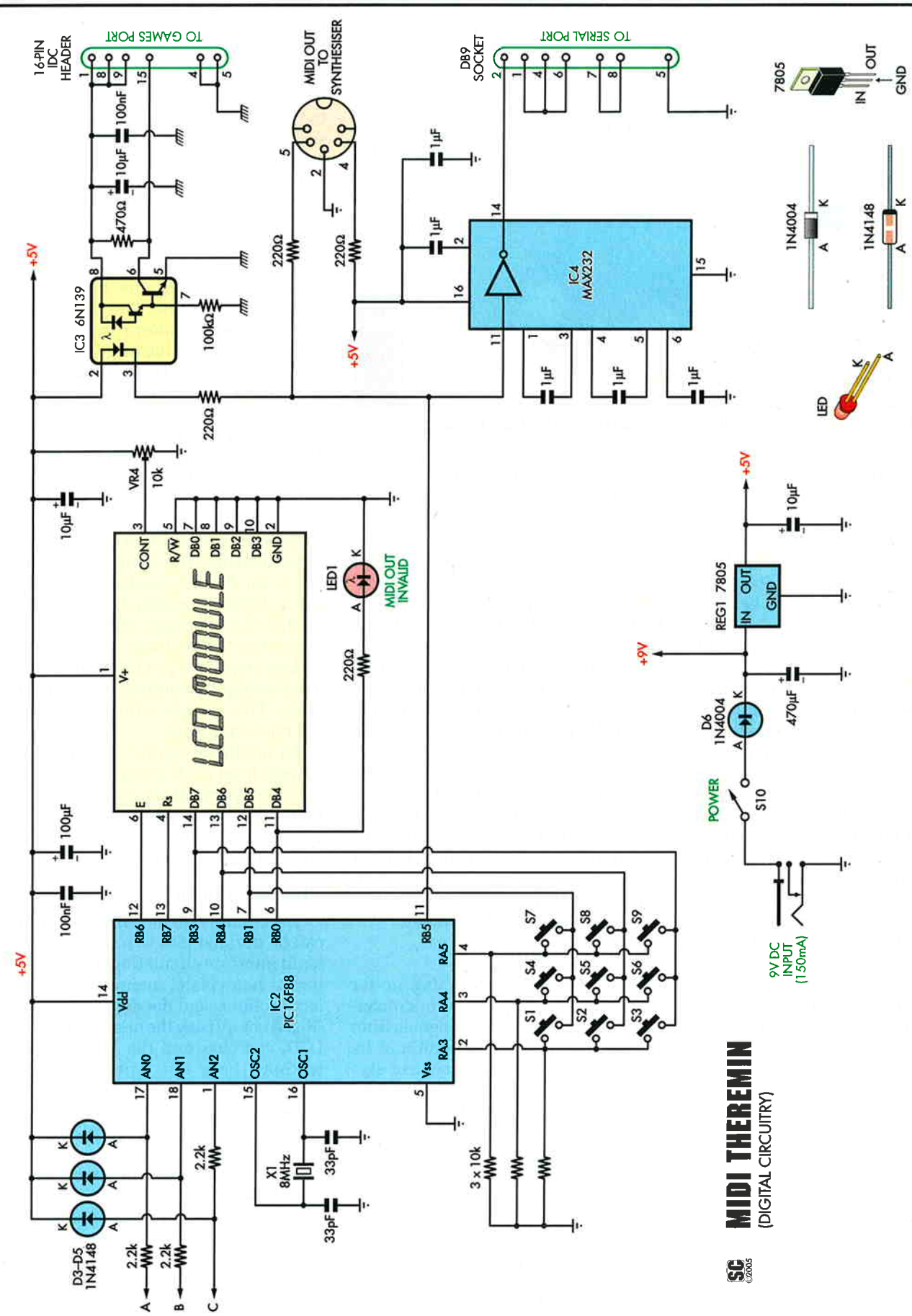
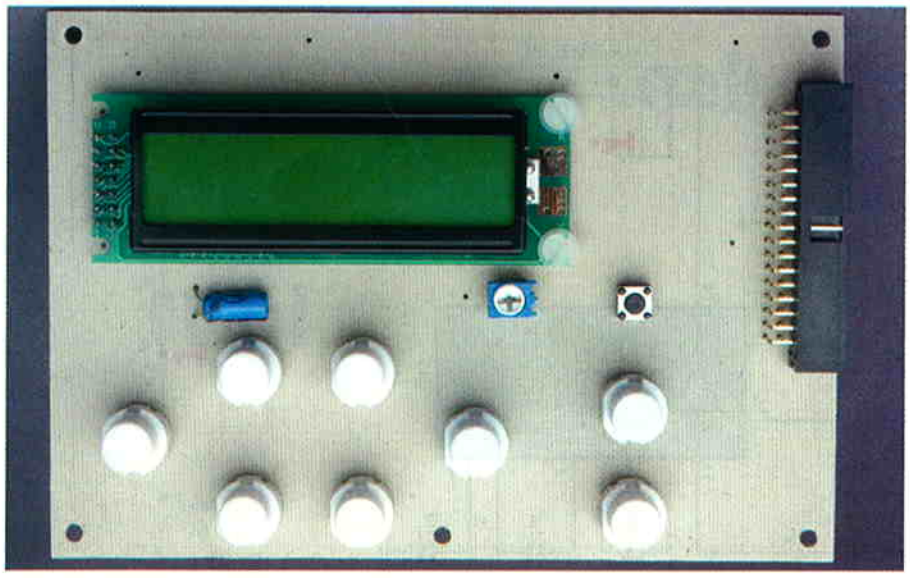


Figs.3 & 4: the complete circuit for the MIDI Theremin. Because it occupies two pages it looks daunting but in reality it can be broken down into a few functional elements. The opposite page (Fig.3) has all the "analog" circuitry while this page (Fig.4) has the PIC microcontroller, the LCD module and the output devices.



The MIDI Theremin display board, which we will construct next month.

times called the Natural or C Major scale. It has an effect similar to running your fingers up and down the white keys on a piano. Selecting sharps (the black keys on an organ or piano) increases the number of notes and reduces the distinctiveness between each note.

There are no sharps between the B/C and the E/F notes.

The final selection with the Effects switch is to change the function of the antenna and auxiliary input. The normal setting is shown as PLATE/ANT./AUX. on the top line, indicating the hand plate, antenna and auxiliary inputs. The second line shows <VOL/NOTE/PITCH>. This shows that the hand plate is for volume, the antenna for note and the auxiliary pot is for pitch glide adjustment.

Pressing the < or > switch will change the settings to <VOL/PITCH/NOTE>. The top line will remain as before with PLATE/ANT./AUX. shown on the top line. For this setting, the hand plate remains as the volume control, but the auxiliary potentiometer is now used to select the note.

The antenna controls pitch over a small range. This is indicated when the Instrument/Note selection is showing Volume, Note and Pitch.

Pitch can be varied over a -500 to +500 range in steps of 1. The actual values do not mean much since synthesisers are not calibrated as far as the pitch adjustment range is concerned.

In practice, pitch varies by more than one note above and below the currently set note. It is important to set the auxiliary control so that the note will not skip to the next note.

Port selection

The Set Port switch is recessed within the box and needs to be accessed using a pen or similar object. It allows the MIDI Theremin to be set up to provide MIDI signals from the MIDI outlet and the games port or a pseudo-MIDI signal via the serial outlet. You can press the switch when the MIDI Theremin display is showing the instrument or note.

The display will then show <DRIVE> VIA MIDI OUT & GAMES PORT or VIA SERIAL PORT ONLY. You can select one or the other using the < or > switches. The MIDI Invalid LED will light when the serial port is selected.

Press the Instrument/Note switch to exit from the port setting mode.

Block diagram

Fig.1 shows the block diagram for the MIDI Theremin. A PIC microcontroller is used to monitor signals from the hand plate control section at its AN0 input, the antenna control section at its AN1 input and the auxiliary control at the AN2 input.

In response to these signals, the micro produces a MIDI signal which is applied to an optocoupler (IC3), the MIDI output socket and the RS-232 converter. The optocoupler provides isolation between the MIDI Theremin and the computer connection via the games port. This prevents hum loops if the MIDI output is also connected to a synthesiser.

The RS-232 converter changes the 0-5V signal from the microcontroller to a nominal ±10V signal for the serial port. When using the serial port connection, the MIDI invalid LED lights to indicate that the MIDI signal on the serial MIDI socket is not able to drive a synthesiser.

The microcontroller also drives the LCD and monitors switches S1-S9.

Oscillators

There are two identical variable oscillators, one for the hand plate control and the other for the antenna control. The oscillators run at a nominal 455kHz, reducing in frequency as your hand moves closer to the plate or antenna. The frequency reduction is due to extra capacitance from your hand being applied to the oscillator circuit. The oscillator output is fed to a bandpass filter.

When the frequency drops as your hand moves closer to the plate or antenna, the filter begins to attenuate the signal because the frequency moves out of the filter's pass-band. The signal is detected (rectified) and filtered so that the bandpass filter output is converted to a voltage. This voltage is then amplified and level-shifted so that the amplifier output covers a 0-5V range. This voltage is then applied to the microcontroller.

An auxiliary control can alter the voltage from 0-5V using potentiometer VR3. Alternatively, an external (eg, foot-controlled) potentiometer can be plugged in. If this is used, VR3 is automatically disconnected.

Circuit details

The circuitry for the MIDI Theremin can be divided into two sections: the hand interface circuit (Fig.3) comprising the hand plate, antenna and auxiliary sections; and the digital circuitry (Fig.4) comprising the microcontroller, LCD, switches and the MIDI output sections. Let's start with Fig.3, the hand interface circuit.

Both the hand plate and antenna control sections are identical and use standard intermediate frequency (IF) transformers as used in low-cost AM radios. Each transformer has a tapped winding with a capacitor connected in parallel, forming a tuned circuit.

The variable oscillator for the hand plate comprises T1 and Q1 (a JFET), plus associated resistors and capacitors. The JFET drives the portion of the

coil between pin 2 and ground.

The full winding signal is applied back to the gate of Q1 via a 68pF capacitor (positive feedback) to ensure oscillation. The hand plate is connected directly to the top of the T1 tuned circuit winding. As you move your hand near the plate, the extra capacitance across the tuned circuit reduces the oscillator frequency.

A second winding on IF transformer T1 couples the oscillator signal to the base of transistor Q2, via a 390pF capacitor. Q2 drives IF transformer T2 to provide a bandpass filter centred on 455kHz. Because it has a sharp rolloff above and below 455kHz, it provides a signal output level that varies widely in response to small changes in input frequency.

The 455kHz signal from T2 is rectified by diode D1 and filtered with the 2.2µF capacitor. This produces a DC level that is proportional to the hand plate oscillator. At this stage, the voltage levels are around 0.9V, dropping to around 0.83V when your hand is near the plate. This is amplified by op amp IC1a to give a 5V swing.

Trimpot VR1 adjusts the output from IC1a so that it covers the range from above 5V down to 0V.

The antenna circuit operates in exactly the same way as the hand plate section, using op amp IC1b, together with trimpot VR2.

The auxiliary input is provided by potentiometer VR3, which is connected directly across the 5V supply. Therefore, the wiper of this pot can produce a variable DC level anywhere between 0V and 5V, depending on its setting.

VR3 is normally internal but can be made external (eg, used like a wah-wah pedal) via a 6.35mm switched stereo jack socket. When the plug for the external potentiometer is inserted into the jack socket, the internal pot is switched out of circuit.

Digital circuitry

The digital circuitry comprises IC2, IC3, IC4 and the LCD module, as shown in Fig.4.

IC2 is a PIC16F88 microcontroller from Microchip. It is a direct replacement for the PIC16F628A, with more memory and a 10-bit multi-channel analog-to-digital converter (ADC), making this device ideal for our MIDI Theremin.

It also has a serial output that can produce MIDI format signals at a 31.25kHz baud rate, with the required stop and start bit. The serial output can also be set to provide the 38.4kHz signal suitable for the serial port on a computer. Either of these two baud rates is accurate when the microcontroller operates at 8MHz, as set by crystal X1, between pins 15 and 16.

IC2 monitors the sensor signals from the hand plate, antenna and auxiliary potentiometer control, at its AN0, AN1 and AN2 inputs.

Diodes D3, D4 and D5 are included to add to the existing internal clamp protection for these inputs, while the 2.2kΩ resistors provide input current limiting.

The Enable and Register Select inputs on the LCD module are driven from IC2 using the RB6 and RB7 outputs. The data input lines are also driven by the RB0 to RB3 lines from IC2. The LCD module has eight data lines but we are only driving the upper four bits (DB7-DB4).

This means that the data must be sent as two 4-bit blocks in order to drive the display. The Enable input and the Register Select input are control lines to place characters on the display and to set the character position.

When the RB0 line is not driving the display, it drives the MIDI Invalid LED1 either on or off. If the LED is set to off, then the fact that the DB4 data line to the display is also being driven does not light LED1, since it happens in short bursts.

RB5 from IC2 is the serial output. This provides the MIDI signal for optocoupler IC3 and the MIDI output socket. When the circuit is connected to the games port on a computer, pin 8 of IC3 is connected to the computer's own 5V supply.

IC4 provides the RS232 conversion for the serial signal.

In short, the MIDI Theremin is a very powerful instrument in its own right and we imagine it will become very popular indeed with bands, orchestras and anyone interested in either playing or experimenting with synthesised music and sound effects.

That's enough to for this month. Next month, we'll give the construction details and describe how the Midi Theremin is set up and used. **SC**

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A nostalgic look Colour TV in Aus

Last month, we looked at some of the interesting changes that the introduction of colour TV brought to the service industry some 30 years ago. This month, we're looking at some of those "interesting" locally-made colour TV sets . . . then again, for those in the industry at that time (and since), the word "interesting" is not the first adjective you'd use!

BEFORE THE WHITLAM Labor government announced sweeping changes to the tariff systems covering imported manufactured goods and components, there was a general agreement in the industry that colour TV sets would cost somewhere between $1200 and $1500 (ie, approximately 10 times the average gross weekly wage!). Moreover, there would probably be no more than five basic chassis designs: Philips, Sanyo, Panasonic, Thorn and Pye.

Of course, the changes to the tariff structure changed this drastically and these prices were drastically revised. In a bid to level the playing field a bit, Telefunken, the owners of the PAL patents, enforced a 6-month moratorium on the direct importation of colour sets with screen sizes of 51cm or less, from the date the first official "limited" broadcasts started in late 1974.

The locally manufactured line-up for 1974 consisted of the Philips K9, the Kriesler 59-01 (basically an electronic clone of the K9 but with different board layouts), the AWA/Thorn 4KA (an antipodean-ised version of the UK "hot chassis" Thorn 4000 series), the Panasonic 2000 chassis, the Sanyo CTP7601, the HMV C210, the PYE CT25 and the Rank Arena (NEC) 2601 and 2201.

Notably absent were any locally-made models with remote control, absurd though that may sound now. The problem was that remote control necessitates a varicap tuner and because Australia has a number of "oddball" TV channel frequencies that are not used anywhere else in the world, there was nothing available that could tune in all the Australian channels. There were some up-market fully-imported European models that did offer remote control but sales-wise they were problematic, because you couldn't guarantee they would work everywhere.

The first remote controls used ultrasonic transducers and were big, clumsy and unreliable. It wasn't until the appearance of infrared models in the 1980s that they started to become standard equipment.

Philips/Kriesler

The Philips K9 was a fascinating mixture of the antiquated and the futuristic. It featured a choice of 56cm and 66cm 110° delta-gun tubes, with an incredibly comprehensive convergence panel. When this worked, it gave very good results indeed and in fact K9s were widely used in TV studios as inexpensive substitutes for "studio" monitors. Sadly, its very complexity was also its downfall. It was the same

at the start of tralia

Part 2: By Keith Walters

old story – the more things you put in, the more things there are to go wrong! Nonetheless, a fully-working 66cm K9 forms part of my "living museum"!

The video drive to the picture tube used the "colour difference principle" – ie, a high-voltage luminance signal was fed in parallel to the three cathodes, while separate R-Y, G-Y and B-Y signals were fed to the appropriate control grids. Although this was common practice with earlier all-valve colour TV sets overseas, the K9 was the only mass-market all-solid state design I am aware of that used this technique.

Some time before this, Philips had decreed that the way of the future was highly "modular" chassis design, with most of the active circuitry contained in small plug-in units reminiscent of the "motherboard/expansion board" approach of PCs. You weren't supposed to try to repair them and none of the Philips circuit manuals included schematics of any modules used.

The K9 used a large number of these modules and naturally they wanted to charge an arm and a leg for replacements! Fortunately, Kriesler (owned by Philips) used a similar module system with almost identical circuitry and pin layout but their modules were physically larger and meant to be serviced. More importantly, Kriesler included the module circuits in their manuals, which were "close enough" to the Philips ones!

Like many of the other locally-made designs, the K9 also featured something else new and frightening: a switchmode power supply. Although all TV sets made these days (as well as VCRs and DVD players) use that technique, in 1974 this was something we'd only read about in English TV servicing magazines and then with reference to only one TV chassis – the Thorn 3000 series!

When it's all said and done, the Philips engineers got it mostly right with the K9, since as far as the power supply and deflection systems go, modern colour TV sets are remarkably similar to the classic Philips design, albeit with most of the discrete transistors now packaged into ICs. The Australian version of the K9 was unusual in that, while the power supply itself was "hot", it had an isolated secondary winding, which meant the rest of the chassis was "cold". With the modern requirement for direct A/V inputs, this is standard practice now but the original Dutch version of the K9 had a hot chassis.

The Kriesler models were basically very similar to the K9, although they'd dispensed with the colour difference drive and just used direct RGB drive to the tube. Kriesler also specialised in the manufacture of "prestige" models with elaborate teak veneer cabinets. Some of these cabinets were so good that a friend of mine used to make extra money "refurbishing" them for a large department store, basically by "retro-fitting" them with the innards of a modern plastic-cabinet TV!

And now for something completely different . . .

Then I suppose if you want to go from the sublime to the ridiculous, we also had the HMV C210. Unlike the K9, this was a veritable tour de force of dead-end design, in particular the use of a Thyristor-based horizontal deflection system.

The story behind this technique is quite fascinating and not terribly well known. First of all, in most countries, the bulk of valve TV sets did not use power transformers, a tradition the manufacturers were keen to maintain with their solid-state designs. The valve heaters were connected in series directly to the mains through a suitable "ballast" resistor and (usually)

Many of the early colour TV sets were real pieces of furniture, built to quite high standards of joinery. This AWA set (sorry, AWA Deep Image Colour set – what ever that meant!) was typical of the genre.

the 200V or so main HT line was derived by half-wave rectification on the mains. (You may have read about valve radios being configured the same way in the vintage radio column).

With any "conventional" horizontal deflection system, (ie, using either a pentode valve or a bipolar transistor as a 15,625Hz switch), there is an approximate 10:1 correspondence between the HT rail voltage used and the flyback pulse generated across the switching device. For example, a 100V supply rail will produce 1000V flyback pulses, 120V will produce 1200V flyback pulses and so on.

It's no trouble to produce power valves with breakdown voltages of thousands of volts, so they could be run more or less directly off rectified 240V mains. In fact, most valve horizontal stages used a so-called "HT Boost" circuit where the input HT voltage was stepped up to 500V or so by the horizontal damper diode. This had a number of advantages but in particular, manipulation of the grid bias of the output valve allowed the boosted HT rail voltage to be regulated by a feedback loop, which both stabilised the width and filtered out any residual mains ripple. They were in fact an early form of switchmode power supply.

Unfortunately, this approach is not possible with transistors. There is a definite technological brick-wall you run into with silicon which makes it impractical to manufacture transistors with breakdown ratings much above 1500V.

This means that the maximum supply rail voltage is limited to around 150-160V. This was all perfectly splendid with the US 117V AC mains, since that voltage could be directly rectified and filtered to produce around 150V DC, which could then be regulated down to 110-120V, giving a comfortable 1200V flyback.

Thus most US and Japanese sets were "hot chassis" designs, often using a simple linear series regulator.

With European 220/240V mains voltages, this was not possible. The raw rectified DC would be something over 300V; getting this down to 150V or so with a linear regulator at the typical current of 1A would give a dissipation of around 150W! Some manufacturers experimented with using two 1500V horizontal output transistors in series but this was a tricky and expensive option.

The most common approach in Europe was to use a single thyristor as both half-wave mains rectifier and voltage regulator, which worked on much the same principle as a light dimmer. The thyristor simply held off conducting until the positive mains cycle had passed its peak and dropped back to around 170V or so.

Although these worked well enough, the various electrical authorities weren't too thrilled about the way they chopped up the mains waveform, and so the manufacturers, particularly those with a sizeable export market, began to look for alternatives.

The Japanese for the most part took a pragmatic approach and simply fitted their European export models with stepdown transformers. This allowed them to retain their tried and proven series regulators and in fact, their European designs weren't all that different from their NTSC models.

Philips, as mentioned earlier, went for the new-fangled switchmode power supply, while others tried a more exotic approach, using a Thyristor-based horizontal deflection developed by RCA in the mid 1960s.

The full operation of a Thyristor (SCR) based horizontal deflection system is extremely complex but essentially, the energy is fed into the deflection yoke during the flyback period, something in the manner of a Capacitor Discharge Ignition system. The yoke winding then essentially "coasts" through the visible scan period, using a network of switching diodes and a second SCR to produce an approximation of a sawtooth scanning current.

In the 1960s, there was considerable doubt over whether it was even possible to manufacture silicon transistors with a breakdown rating of much over 500V, so for a while it seemed that the only practical way of making an all-solid-state colour TV chassis was to use a big (and heavy) mains stepdown transformer.

RCA's SCR horizontal deflection system was first demonstrated in 1967, as a possible solution to this problem. An unregulated +140V HT line derived directly from the 117V mains was fed to the flyback Thyristor via a saturable reactor, which basically formed the control element of an electronic regulator system. Without going into too many details, flyback pulses of about 120V amplitude were applied to the horizontal deflection yoke, resulting in a peak-to-peak scan voltage of about 24V. This operation is basically the reverse of that of a conventional line output stage.

Although the system did work, it never caught on for a number of reasons. First of all, although the basic principle was simple enough, the actual circuitry needed was quite complex, requiring several large ferrite inductors and high-value polyester capacitors.

Because of the very low scanning voltage used, the yoke current peaked at over 100A in large-screen sets, which meant extreme care was needed in manufacture to avoid dry solder joints, as the slightest resistance would result in major burn-ups. There were

also severe problems with "spooks" (line frequency harmonics) causing interference on the screen.

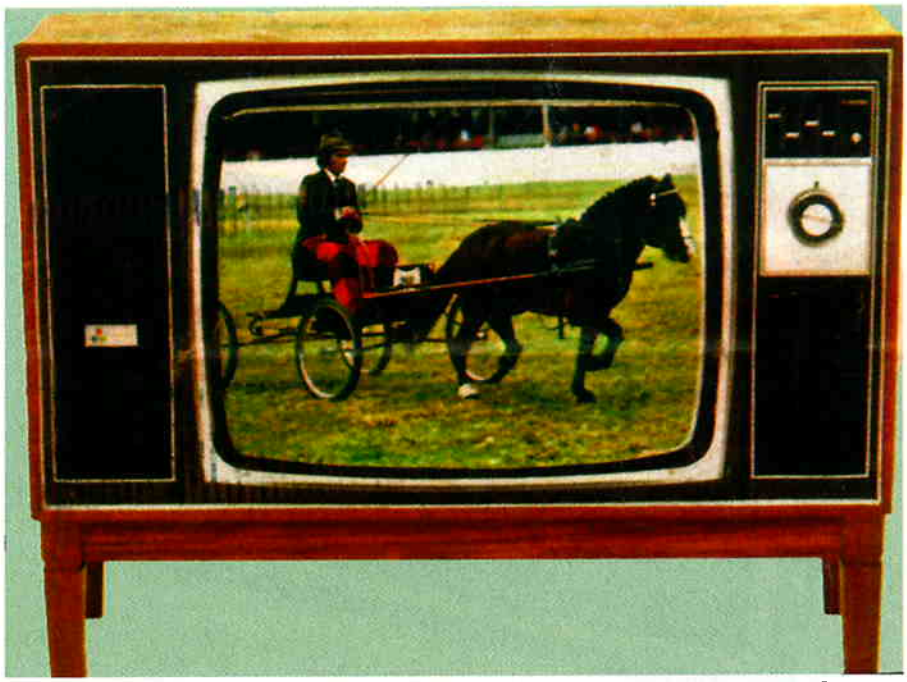
Ironically, it was RCA themselves who finally sealed the fate of the original system, when in the late 1960s their semiconductor division managed to produce power transistors with a 1500V rating, using a design not all that different from what is still standard today. US (and Japanese) solid-state designs thereafter tended to use bipolar transistors with a linear regulated power supply.

However in Europe, the SCR line output stage was re-invented in the early 1970s, with a new three-SCR design. This also was designed to run from filtered but unregulated mains-derived DC (this time from 220-240V mains) but in this case, a special flyback circuit stepped this voltage up to somewhere between 450V and 600V. The third SCR regulated this boosted voltage by bleeding a variable proportion of it back into the main unregulated supply during the horizontal scanning period.

The revised system worked on much the same principle as the earlier RCA one but because it applied higher voltage flyback pulses, a more conventional (cheaper) yoke design could be used. However, the Australian HMV C210 would have to take the biscuit as an example of taking the worst features of two technologies and combining them!

The C210 used the old-fashioned two-SCR design but they also used a switch mode power supply, which meant the main feature of the SCR design – the built-in voltage regulator function – wasn't actually used! The lack of a boosted HT rail also meant that they had to revert to a special low-impedance scanning yoke, with all the inherent problems of heavy circulating scan currents, dry joints and so on.

Worse still, for the switchmode power supply, they chose a peculiar self-oscillating design which, while economical to build, was barely good enough to drive a set with a conventional transistor horizontal output stage. SCR line output stages are notorious for occasionally drawing unpredictable and extremely heavy supply currents during start-up; in fact many sets that used them were equipped with mechanical circuit breakers as an afterthought! The C210 power supply



This 1975 26-inch Lowboy Thorn 9064 also boasted "twin hi fidelity speakers" and a quality timber cabinet. As with most sets at the time, it was VHF-only.

was one of the least reliable on the market; it just couldn't cope with that sort of hammering.

To be fair, when the C210 chassis worked, it was quite a good set but they were hopelessly unreliable and easily the worst set on the Australian market in this regard.

The new "Euro-version" three-SCR line output stage fared somewhat better but manufacturers very quickly dropped the technique, out of simple economics if nothing else! When it was all said and done, it was simply cheaper to use a switchmode power supply and a transistor horizontal output stage and a damned sight more reliable!

But then a strange thing happened. Just when we thought the SCR line output stage had been relegated to the industrial bin of history, the Japanese cottoned onto the idea! After a fairly uneventful start with quite conventional designs, in 1975 Sharp started the ball rolling with a truly awful chassis called the C1831X. These were smart-looking little sets with state-of-the art 18-inch 110° inline-gun tubes, and performed very well. But after a year or so (presumably as the electrolytics started to dry out), they started to fall over like flies.

And they were just about unfixable! It was the same sad story as with many other SCR designs: you replace everything, and it still blows up at switch on! Apart from that, they had appalling chassis access, making them almost impossible to service in the home. From memory, I think they were the only colour sets we wouldn't accept under service contract!

But to give them credit, Sharp quickly realised the error of their ways and went over to the tried and proven switchmode power supply/transistor line output system.

However, just when we thought it was safe to go back into the workshop, National (now Panasonic) decided to have a go, or show Sharp how it was done, or something!

It was the same story – plagued by dry joints, blown up by even slightly tired electrolytics and "spooks" on Channel 0. Well, the flirtation didn't last loo long there either and the SCR line output stage finally bit the dust!

The C210 was such a disaster that HMV soon started selling fully imported British-made sets using the "Decca 33" chassis. This had the distinction of being the only mass-market colour TV sold in Australia with valves in it! After their flirtation with "hi-tech" SCRs, obviously HMV weren't about to take any more chances!

Ironically, they were damn good sets! In a store display, the Decca 33 would always stand out for picture quality and they were considerably more reliable than many of their all-solid-state competitors. This was

The C2201 was the first Rank Arena set available in Australia, along with the C2601. They were very successful and "The Bulletin" magazine reported that Rank Arena had 17% of the colour TV market in 1976.

probably at least partly due to the fact that they were fitted with power transformers with a special winding that provided the exact voltage needed for the series heater string, rather than a dodgy dropper resistor.

Their presence in the market also provided a handy source of valves for all the "odds and sods" colour TVs brought in to Australia by European migrants!

The Thorn 4KA

This chassis was almost as unreliable as the C210 but at least there was a reasonable possibility of fixing the 4KA and having it keep working long enough to get it out the door!

I think the 4000 chassis would have to be a leading contender for the most over-designed set in television history! Admittedly, the K9 was a pretty complex beast but at least they mostly used common parts and they didn't break down all that often. In fact, while there are quite a few K9s still working even to this day, I don't know of anybody who had a working 4KA past 1990!

The 4KA was the "Ocker-ised" version of the English Thorn 4000 chassis. The UK version had a live chassis and used a full-wave rectifier (ie, it was "hot" which ever way round the mains Active and Neutral leads were connected). For Australia, they simply fitted it with an isolation transformer, a move which was adopted by a number of European manufacturers as the easiest way to make their sets meet local safety standards.

It's interesting to ponder just what went through the designers' heads when they came up with the 4000. Like most of the locally-made sets, it came with a choice of 56cm or 67cm 110° picture tubes but unlike most of the other manufacturers' offerings, these were a special RCA narrow-neck delta gun tube (which didn't seem to work any better than the standard wide-neck Philips tubes). The matching deflection yoke was also from RCA and was originally designed for use with a Thyristor line output stage. That plus the fact that the 4000 uniquely had separate horizontal output and EHT generating transistors strongly suggests that it was originally meant to use SCRs in the horizontal deflection section.

The 4000 also had an incredibly comprehensive set of convergence controls, all brought out via a monstrous cable to a paperback-book-sized hand-held control box that could be unclipped and brought round to the front of the set. Instead of the usual conglomeration of variable inductors and wire-wound pots, the controls were all thumbwheels similar to those on a pocket radio. They were clearly marked with their functions and were a delight to use when the thing was working properly which sadly, wasn't all that often!

Thorn had developed an unfortunate fixation with thick-film modules, which still live on today in the form of the ubiquitous "Sanken" audio amplifier modules.

The notion was fine in theory: a resistor network could be formed onto an insulating ceramic substrate, trimmed with a laser, connecting wires, transistors and other components soldered on, and then the whole assembly dipped in epoxy. The idea was that complete circuit modules could be built this way and the heat-conductive ceramic substrate would ensure that all the components were kept at the same temperature and so avoid thermal drift problems.

There were several of these in the 4000 chassis and they were all hopelessly unreliable. Towards the end of the 4KA's production life, AWA-Thorn started substituting small circuit boards which were far more reliable but suffered horrendous thermal drift problems. The static convergence would often drift 5mm during warm-up!

The 4KA also had tremendous problems with its chroma decoding circuitry. This must have started fairly early in the piece because the subcarrier oscillator and chroma processing circuitry were all located on a small plug-in board and several different boards were used, none being particularly reliable.

I think the original idea was to have an elegant state-of-the-art two-chip colour processing system: a TBA395 for the chroma processing and subcarrier oscillator and an MC1327 for the decoder and output, but Thorn just couldn't get it to work properly.

The 4KA was so unreliable that, in 1975, following HMV's lead, AWA-Thorn started importing British-made 56cm and 67cm sets using the older Thorn 3500 chassis. Although this seemed like a huge step backwards for many, at least these sets with their antediluvian 90° delta gun tubes and strange transistor types were reliable and properly set up, they gave an excellent picture. The Australian version

of the 3500, (dubbed the 3504) was fitted with an isolation transformer and a standard 13-channel VHF tuner.

The above three models were probably the most noteworthy/notorious. Most of the other brands simply behaved themselves and so there's not much to say about them really. That is, while there were certainly a lot of these sets sold, they were not, as the police might put it, "models of interest" to us!

National

National's (Panasonic) first entry was a chassis known locally as the 2000 (also "M4"), which appeared in several screen sizes and models.

This chassis was actually the very first locally manufactured colour set I ever saw and I still have a working 56cm sample in my collection! It seemed the Matsushita designers didn't want to miss out on anything, since this chassis had a mains stepdown transformer, an SCR voltage regulator and a bipolar transistor as an electronic filter, which sadly, were the only unreliable parts of these otherwise excellent sets.

Our first reaction was one of abject horror when we saw how the chassis was constructed though, with quite poor service access!

Pye

For a home-grown effort, the Pye CT25 was quite well-designed and relatively trouble free and unlike many of its "countrymen", these sets tended to stay the distance.

Unusually for a "Euro-centric" design, it used a simple mains stepdown transformer and a Japanese-type series regulator for its 120V HT rail. Pye were also unusual in using an inline gun picture tube from the start; other manufacturers took a couple of years to catch up.

Otherwise, there was nothing whatever unusual about its circuitry, which is probably why so many of them lasted so long!

Sanyo

Another chassis that was "underrepresented in crime statistics", the Sanyo was another fairly conservative effort, with a simple linear regulator power supply using two transistors in parallel.

There are still a few of these in operation today, although at some point they would be in need of a bulk electrolytic transplant!

One of the early Philips colour sets – this was taken from an advert at the time complete with the then-standard "simulated picture" disclaimer . . . did they think that viewers would complain if the yacht sail did *not* poke out of the top of the television when it was installed in their loungeroom?

Rank Arena

These sets were basically a locally assembled version of an NEC chassis. The story went that a consortium of local manufacturers was offered the choice of the British-designed "true" Rank chassis or a badge-engineered NEC chassis. Legend has it that they took one look at the British effort and took the NEC option!

Although the NEC chassis worked reasonably well, construction-wise they were a bit of a mess, the earlier designs being pretty much an NTSC chassis with extra circuitry tacked on for PAL decoding.

They were less reliable than most of the fully-imported Japanese sets, but they were cheap and cheerful and most customers were satisfied with their purchases.

Their only real vice was that the insulation around their EHT triplers often used to fail without warning, unleashing a noisy fireworks display that traumatised many a snoozing household pet (and its owner!)

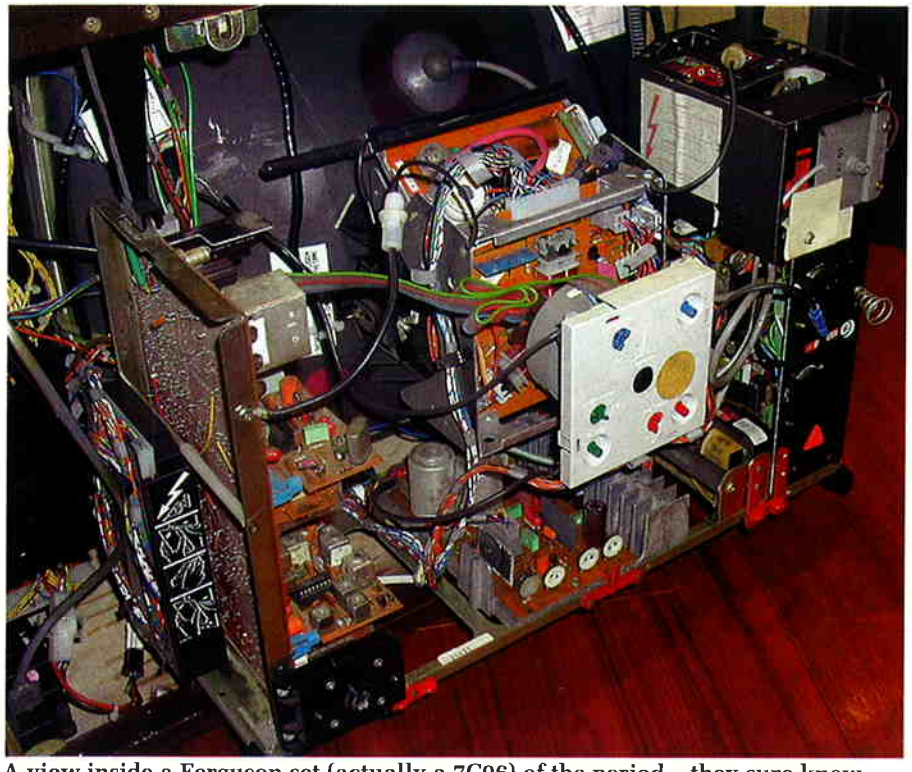
The Japanese invasion

To give the local manufacturers a sporting chance, Telefunken, the owners of the PAL patents, enforced a 6-month moratorium on the importation of sets with screen sizes 51cm and under, until the actual commencement of full-time colour broadcasts in March 1975.

As I said, we had good reason to fear an onslaught of cheap Japanese-made sets, in light of our experiences with their monochrome efforts!

I was working for AWA-Thorn when the imports began and we were frankly left open-mouthed when the first container of 1000 AWA-branded (and Thorn) 34cm Mitsubishi portables duly arrived – not with horror but rather with amazement. Every single one of them worked!

OK, a couple of them had purity errors that needed a touch of the degaussing wand and one or two of them had minor static convergence errors, but compared to what we'd been used to, this was unbelievable! With the 4KAs, as each shipment arrived from Sydney, it had become standard practice to take them all out of their cartons, sit them on top, and let them run without antenna input for about two weeks! Out of every lot of 100, after the first day there'd typically be 10-15 blank screens (some of which responded to switching off and then on again) and an equal number of screens with snow some colour other than white! Each day, the number of duds was a little bit



A view inside a Ferguson set (actually a 7C06) of the period – they sure knew how to fit a lot in in those days! Of course, most of what you see in today's sets would be replaced by a couple of large ICs and a few other components.

smaller, until eventually a week could go by without failures. Of course, then we'd go round plugging in an antenna, and the fun would start again!

The story was the same with just about every Japanese import: for sheer reliability and price, the Japanese were simply unbeatable. If I had to make a choice, I'd say that JVC gave the best all-round package of appearance, image quality, reliability and value for money. Apart from a couple of notable exceptions, you really couldn't go wrong!

Actually, "Dad's TV" is a bit of a family joke that is a case in point. My father turned 70 in July 1975 and so my brother and I decided we'd go halves in buying him one of the new "AWA" 34cm portables. I actually paid the "dealer price" of $333, which in those days was a ludicrously low price for a working colour TV set! He was as pleased as punch and as he was bedridden a lot of the time. He didn't expect to be with us much longer and so he kept remarking that the little set would "see him out!"

However he got over that illness but true to his word, when he finally passed on 28 years later in September 2003, aged 98, the set was still going, with the picture tube as good as the day we bought it! What's most remarkable is that it only ever broke down once in all that time (after 22 years).

Recently I saw an identical set at a flea market for the princely sum of $5 and I bought it for spare parts. Would you believe that when I got that set home, I found it was also still in working order? After a few minor adjustments, it is also producing as good a picture as it did the day it was made – just like the 56cm version of the same chassis which I found during a council clean-up 10 years ago and fixed for a few dollars!

There's another bit of irony here too. Many of the first wave of imported sets had the "instant picture" facility, where about 4V ("standby") was applied to the CRT heater while the rest of the set was off. This heater voltage was then increased to the normal 6V when the set was switched on.

Grave concerns were raised as to the effect this "convenience" feature might have on the longevity of the picture tube cathodes, particularly if the set was to be taken under service contract.

Well now we know! All of the sets I've seen with tubes still in perfect condition after 30 years were the ones with this feature! Far from shortening the life of the cathodes, it seems to have done them a power of good!

Bypass operation

One of the weirder aspects of the Telefunken's attempts to regulate the market via their control of the PAL patents was the "PAL bypass" fiasco.

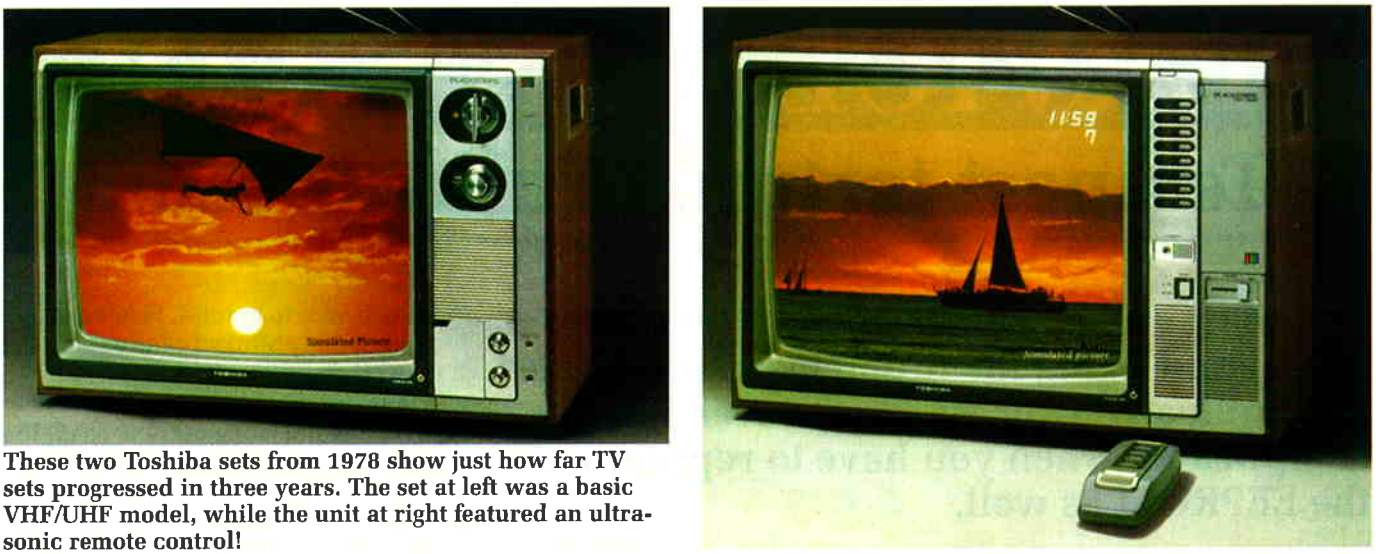
In 1968, Sony announced the development of their revolutionary Trinitron picture tube. It certainly produced the best pictures available at the time, and Sony caused a lot of concern with their announcement that they would not be licensing the technology to any other manufacturer, presumably hoping to corner the market.

However, in retaliation, Telefunken refused to issue Sony with a license to manufacture PAL receivers, effectively locking them out of the lucrative European market. Sony then announced that they had developed a chroma decoder that didn't actually infringe on the PAL patents, because it essentially turned the PAL signal into NTSC.

The upshot of this was there were a few fully-imported sub-51cm sets imported into Australia before March 1975, some by Sony and a few from Mitsubishi. Because they didn't actually use PAL decoding, they were prone to the "green faces" problem of NTSC, although properly set up, I doubt that too many people would have noticed the difference.

However Telefunken insisted that these decoders did in fact infringe on the PAL patents, as they relied on certain characteristics of the PAL signal to determine which lines held PAL encoding and which held NTSC encoding. In the end, Telefunken relented, after experience with the US NTSC market showed that consumers weren't all that impressed with the Trinitron tube, not if it meant paying substantially more for the technology! Apart from that, neither the Sony sets nor the Trinitron tubes turned out to be particularly reliable, and even after the Trinitron patents lapsed, no other manufacturer seemed interested. It's rather sad now after all this time to see "Badge Engineered" Sony-branded TV sets with ordinary tubes in them.

One of the minor mysteries of all this carry-on cropped up when HMV started selling small Japanese-made "General" colour sets under the HMV and Healing brands. There was nothing particularly noteworthy about these sets except that they used a



These two Toshiba sets from 1978 show just how far TV sets progressed in three years. The set at left was a basic VHF/UHF model, while the unit at right featured an ultrasonic remote control!

"weirdo" two-crystal PAL chroma decoder system that would almost certainly have successfully sidestepped the Telefunken patents but they also used a perfectly standard PAL delay line system that most emphatically would not! It seems almost as though they changed their minds half way through!

The beginning of the end

The start of unrestricted importation of cheap colour sets pretty much marked the beginning of the end for the larger TV service companies. When colour was first on the horizon, the local manufacturers began to work out warranty service deals with the service companies and prices were agreed and so on, but this was on the basis of the original estimates of colour set prices before the tariff cuts were announced.

With their prices effectively cut in half, the manufacturers naturally wanted to halve the service contract prices as well – but of course, it doesn't work like that. For all practical purposes, the service cost was the labour cost, which remained stubbornly the same!

The result was that most of the manufacturers decided it would be more cost-effective for them to provide their own service departments and that was how I came to be working for AWA-Thorn. Unfortunately, most of them badly overestimated the reliability of their own products, and so their service departments became hopelessly overloaded. The problems were massively complicated by the actions of certain smaller concerns who suddenly started offering cut-rate service contracts to some of the big retailers, who had no way of knowing that these outfits hadn't spent a cent on staff training or upgrading their equipment. It was pretty much a case of "take the money and run", leaving the manufacturers (ie, us) to face the angry customers.

In the current climate of consumer protection laws for everything, it's hard to imagine what it was like back then. In those days it was perfectly normal for a customer to spend up to a thousand dollars on a colour TV set, have it fail the very first night, and then have to wait days or weeks for someone to even come and look at it! I had to make many a late-night house call with a 4KA chassis on the back seat of my car!

Of course, with the wafer-thin profit margins involved with the new cheap imports, the importers/manufacturers were obviously keen to screw an even lower service contract price out of the service companies, which was generally greeted with statements like "Yeah, right!" This was well before anybody realised how reliable the Japanese sets actually were. If the service companies had known that, they could have cleaned up with low-price contracts on sets that never broke down.

So in the end, the importers realised that it was probably going to be cheaper to simply keep a supply of spare sets on hand for replacement purposes or spare parts, which is pretty much the practice today.

By the early 1980s, TV set manufacture had pretty well ceased in Australia, although some manufacturers maintained a "screwdriver industry" presence, basically assembling some of their larger models locally from fully imported components. The arrival of VCRs and things like personal computers revived the fortunes of the servicing industry to a certain extent but slowly it regressed to the "Mom and Pop" style of independent operators typical of the 1950s.

Much the same thing happened in New Zealand, incidentally, although things happened a little differently there.

What used to be one very large service organisation with branches in most of the larger towns, became a sort of "McDonalds franchise" operation, with independently owned branches supplied by a centralised parts buying agency.

It's hard to know where the future lies. In this era of $95 34cm portable TVs, $98 VCRs, $50 DVD players and $495 2.5GHz PCs, obviously it's going to be a lot cheaper to throw things away than get them fixed.

Nonetheless, as "Serviceman's Log" can attest, people are still sometimes willing to pay an over-the-top price to get something fixed, purely on the basis of: "well, I know how to operate that set!"

Organisations like WES Components do a sterling job of keeping small servicing companies in business, combining an enormous parts inventory with fast delivery. It's truly amazing what you can still get parts for!

Having said that, my local electronics repair shop has just closed down for good and that's something that's occurring far too often these days! **SC**

SERVICEMAN'S LOG

Tempest tortures Turkish Teac

Lightning can cause all sorts of damage to a TV set and fixing the problems is sometimes a complicated process. It gets even more complicated when you have to reprogram the EEPROM as well.

I was called to Andrew Twist's 2002 Teac CTW3250S (using the Turkish Vestel 11AK19PRO chassis), which was dead.

This is a 76cm widescreen TV and I knew that if the fault wasn't simple, it would have to go to the workshop. And that would be difficult considering the size of the small hatchback I was driving.

Apparently, Andrew had decided to switch the set off and disconnect it from the mains just as a storm was beginning. However, before he could get to the set, a nearby lightning strike did the job for him!

I removed the back and checked the power supply. Ironically (and typically these days), the 3.15A mains fuse (F801) hadn't failed but R817 (2.2Ω, 5W) had. The bridge rectifier was OK but FET Q802 was short circuit.

Items Covered This Month

- Teac CTW3250S TV set (Turkish Vestel 11AK19PRO chassis)
- Teac EU-80ST TV set (Vestel 11AK19)
- Sanyo CP14SR1-50 TV set (AC5-G14 chassis
- Panasonic Series II Inverter Microwave Oven NN-T790SF
- Panasonic TX51P800H Rear Projection Television (chassis GP1VP)
- Orion 32 DVA TV set (T7800 PRO Series chassis)

Because this FET is DC-coupled to IC802 (MC44604P), the question was had that also blown, along with anything else?

Anyway, that was as far as I was prepared to go in Andrew's home. And having informed him of the facts, I suggested that he contact his insurance assessors.

Unfortunately, he had been going through a rough trot and was only just beginning to get back on his feet. He wasn't insured and really couldn't afford to spend any money. Instead, he simply paid for the service call and told me he would wait until he could afford to have it fixed.

Three months later, he finally dropped the set around to the workshop. Unfortunately, luck hadn't been on his side during the storm. Not only had the control IC been destroyed but also D827 (BA159) which connects to the source of the FET.

This was rather puzzling. D827 is in series with D826 and both are identical BA159 diodes but only D827 had short circuit. I cannot really imagine why – I guess it's just part of the rich tapestry of life and chaos theory.

After replacing D827, the power supply came on but was now pulsating slowly, with a low output. In addition, the red LED wasn't lighting. I checked for shorts in the six secondaries but could find none.

Next, I turned my attention to the +150V rail to the line output stage, where I checked D816 BYM26D (now BYM36D), the line output transistor Q605 and transformer TR602 (which was unlikely to have failed in this instance). I then shorted Q605's base and emitter and hung a 60W globe from its collector to ground. However, this globe merely blinked gently when the power was applied.

Further checking showed that there were low pulsating outputs on all the rails, even when I disconnected them one at a time. This meant that it was time to take a close look at the control circuitry in the switchmode power supply and at microprocessor IC501 – in particular, the circuitry to pin 22 (ST-BY) and pin 33 (RESET).

The supplies to the microprocessor are 3.3V and 2.5V and both these were extremely low. Disconnecting the links to the microprocessor brought these voltages up but still there was no life. Furthermore, shorting one side of R831 to ground should turn the power supply on from standby but it made no difference.

Next, I checked the optocoupler and its control IC zener (TL431), as well as IC804, C818, C704 and C829. However, I wasn't really getting anywhere.

Biting the bullet

It was time to bite the bullet and replace microprocessor IC501 and the EEPROM (IC502). This was all rather confusing, as the service manual lists not one but two different part numbers – neither of which bore much resemblance to the one fitted in the set, the one on the circuit diagram or the ones supplied. I tried them one at a time until I found, naturally, that the most expensive part worked!

I now had some control of the set. The red LED would come on in Standby and flash four times when the set was on and I could do this with the remote. The voltage rails were up a little as well, especially the low 2.5V, 3.3V and 5V rails. However, the 150V rail was still pulsating around the 80V level.

Well, where to next? There was only the line driver and the jungle IC (IC401) left. The latter device is a TDA88441NZ, a big 56-pin device with high-density pins. I had already checked the voltages into this IC and

the clock crystals, so it now had to be changed.

Replacing this IC finally brought the set to life, with picture and sound, but the geometry and picture were all over the place. Just in case I had misdiagnosed, I refitted the old micro and EEPROM which were socketed but it was obvious that these had been destroyed.

Now all I had to do was reprogram the EEPROM. First, you have to get into the Service Mode by pressing the blue INSTALL button and then 4, 7, 2, 5 and go to the Options menu. Once again, the inadequate service manual (which, I might add, lists the CTW3250S as an 11AK19P3 – not an 11AK19PRO as written on the back of the set – and the CTW32505-1 as an 11AK33) does not have a list of option codes for each model. Instead, it has a list of 60 options with eight bits each and you have to work out what is appropriate for your TV.

Fortunately, or unfortunately, options 30-37 and 39-49 are missing, so what do you do about these? And the manual refers to each bit as having a value of 1, 0 or X – X presumably being "I'm not sure?" (many of the choices you have to make from this total lack of information would surely come under this category). The only thing is, the TV won't let you put in X as an option.

For example, Option Ø, Bit B4 Akb = 0))0x02) Hue B6 (Black Current Stabilisation)? and Option 01 Bits B7 & B6 Forf = Fors = 1 (Forced Field frequency auto) (50Hz when line not synchronised)?

As you can see, it's not easy to make decisions based on these criteria! However, I did the best I could, making intelligent guesses, before moving onto the adjustment menus. Here we now have 65 controls to align for 4:3, 16:9, Cinema, Sub-title and Super Zoom settings, again with no real specification to compare with.

Ironically, you cannot use a colour bar generator connection to an AV input as AV is not selectable in the Service Mode. Instead, you have to tune it in first on an RF channel and store it as a program number. For each of the aspect ratios, it doesn't make it clear whether you need a generator that can give signals other than 4:3, nor does it make it clear whether and by how much you must overscan the picture.

By trial and error, I managed to get what I thought was the correct geometry for each size but found the S-correction (adjust 14, 26, 37, 48 and 59) made no difference and I assume that Vertical Slope (adjust 14, 25, 36, 47 and 58) means Vertical Linearity and that EW Parabola Width (adjust 18, 29, 40, 51 and 62) means pincushion.

When it came to setting up "Y" delay for SECAM, NTSC and others, as well as IF-PLL negative adjustment with PLL tuner, I chickened out and left the default values that were already there. Adjust 03 is AGC and was set to 015. After that, I tuned in all the local stations and was quite happy with the results while it was on test.

Andrew managed to con me into redelivering the set and reinstalling it. No sweat – I felt that this shouldn't be too difficult. All I had to do was retune the NEC VCR and connect his Foxtel box.

It all initially went well, despite the millions of stairs and the hassle of moving his other 68cm set out of the way. However, when it came to tuning the set, I ran into all sorts of grief. I selected the Foxtel MENU setting so that I could easily identify it and that went into the pre-tuned VCR (on which I also selected its own menu) and into the Teac.

I was expecting it to come up in two places on the TV and sure enough, it came up fine on Ch65 for the VCR (too close for comfort for Channel 10 on UHF Ch66) and Ch55 for the

Foxtel. However, when I turned off the menu, the picture was shocking, with severe herringbone patterning on both locations.

Andrew kept assuring me that all had been perfect before and that the reception was also perfect on the temporary set he had been using. The only thing I could think of was that perhaps the AGC hadn't been set correctly and that it might be critical in this location.

I went back into the Service Menu and spent what seemed like hours messing with the tuner options and adjustments – all to no avail. In the end I did the "De Bono thing" and thought laterally – if the tuner/tuning is crook, connect everything via the AV sockets. This meant supplying extra AV leads and a SCART adaptor – but it was worth it if would save time to fix the fault.

Well, I did that but Foxtel was still showing a terrible picture. But why? Well, the first thing I noticed was that the simple blue and white menu was fine. It was only while actually watching Foxtel Ch13 that the problem occurred, so I changed the channel and found that almost 90% the other channels were perfect. It had to be a cable fault!

Luckily, Andrew rarely watched Ch13 and someone must have selected it by chance. Anyway, he was delirious and so was I that at last I was out of this particular nightmare.

Another Teac

Later that week, I was forced into attending (for political reasons, to do with Mrs Serviceman) a Teac EU-80ST (Vestel 11AK19) for another client. This was dead and stuck in standby, with the red standby LED on and no other functions working.

As luck would have it, the 80cm set was wedged into an entertainment centre that had to be unscrewed before it could be moved! I can't tell you how much I didn't want to be there but there are times when you just have to do jobs you don't want to do, whether you like it or not (it's called appeasement)!

Anyway, after a struggle, the client and I eventually managed to dismantle his elaborate entertainment centre console and place the TV on a coffee table. I then removed the back and took a "peek-a-boo" inside. The first thing I noticed was that, despite the furniture looking pristine, the cabinet of this 4-year old TV had been badly scratched.

When I looked at the chassis, I also noticed a large number of cracks in the PC board that someone had bridged with jumpers. Faced with this evidence, the client finally cracked (excuse the pun!) and admitted that the set had been dropped some time ago – but it had been working perfectly for a very long time since (where does Mrs Serviceman pick up these people?).

He also admitted that the front controls had not been working for a very long time. However, the remote was fine so he hadn't worried about this.

Well, careful examination of the main chassis and the front control board, which also carried the infrared remote control receiver, showed that plug PL502 had a series of very bad dry joints. I resoldered these and – hey presto – the remote control was back in business and the set could be switched on again. The front control buttons still couldn't be used but I didn't care (it was probably due to a hairline crack). After all, the client was happy and if he was happy, Mrs Serviceman would be happy and perhaps I would get something special for dinner that night!

Microwave ovens too!

Our amazing technician Michael was telling me about an interesting problem he had with a Panasonic Series II Inverter Microwave Oven NN-T790SF.

This problem involved the display. When the START button was pressed, the word prompting display would sometimes show "Welcome to Panasonic", as though the power had been switched off and the microprocessor reset.

He traced this to the mounting screw for PC board 4W7QPT, which had failed to make a good ground connection. The circuit diagram shows pin 2 (centre) of plug CN4 as an alternate ground lead (yellow) but, in fact, the matching pin hadn't been fitted to the PC board in the factory. The fix was to cut and solder the yellow lead directly to D27 instead.

Stubborn Sanyo

Sometimes, the problems I encounter are straightforward and sometimes they are extremely complex. Unfortunately, when a set first comes in you can never tell which category the problems are going to be in.

Recently, I had a "newish" Sanyo CP14SR1(G)-50 (AC5-G14 chassis) come in with the complaint that there was no colour when a DVD or VCR was plugged into it. Well, straight away, I thought that this was going to be easy – the wrong colour format must have been selected for the AV input.

I pressed the Menu button, picture and tuning menus but nowhere could I find a system menu. OK, this isn't unreasonable – after all, this is only a cheap 34cm portable so perhaps it doesn't have this feature.

Next, I had a good look for dry joints, especially around the crystal, and looked for a reference oscillator control that might be slightly out. I couldn't find anything.

Eventually, I noticed that if I ran my fingers down the pins of the jungle IC

(IC201, LA76818A), the colour appeared but I couldn't pinpoint the problem. In the end, I assumed that it was probably the IC, so I ordered a new one. I fitted it as soon as it arrived but "quelle horreur"! – there was no change!

A service manual for this chassis had been ordered at the same time but I could find nothing in it that gave me a clue. The oscilloscope showed the full colour waveform arriving on pin 42 of the chip and the reference oscillator was spot on.

Fortunately, by mistake, an instruction booklet had also been supplied with the Service Manual. And page 17 (near the very back) had the solution!

What you have to do is select the AV input and then the RECALL button on the remote control. This button is marked with a symbol of a TV screen and a bar in the bottom righthand corner and it reveals an AV system menu offering AUTO, PAL and NTSC. Of course, NTSC had been selected and changing this to AUTO fixed the colour problem.

Husband bashing

A husband and wife were having a domestic dispute that began to get a bit out of hand. In frustration, she picked up a glass and threw it at her husband (as you would expect) and naturally he ducked. The glass continued its trajectory unhindered until it came into contact with their brand new Panasonic TX51P800H Rear Projection Television (GP1VP chassis). It hit the middle of the set's 130cm diffuser, severely cracking it.

The diffuser is made of two layers: a front lenticular lens that's worth $300 and a rear Fresnel lens that's worth $400. Add in an extra $220 for the labour charge and . . . OUCH!

Anyway, they lived with this for a while until the set blacked out into Service Mode, with the red LED flashing. This problem was even more severe. The red picture tube had been broken in two when the EHT arced through the crack and onto the deflection yoke winding. Fortunately, these latter items could be fixed under warranty but they had to cough up just under a grand for the diffuser lenses!

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Dead Orion

A dead Orion 32 DUA TV set (T7800 PRO series chassis) was delivered to my workshop without its instruction booklet or remote control, which I always request for

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NSW: • austeksecurity.com.au NZ: • sicom.co.nz (south island) • surplustronics.co.nz (north island)

obvious reasons. The fault was fairly easy to diagnose – the line output transistor had gone short circuit due to an arcing flyback transformer. Both were replaced but on switch-on, there was just a black screen with the program number "PO2" displayed and "Child Security Active".

I couldn't get into the menu to unlock this as only the remote control works in this mode. That meant a delay of a couple of days while I contacted the client, to ask him to drop the remote in.

When I finally got the remote, I found I could activate the menu and go to child safety but I still couldn't remove the message. It was only when I went I went into the service mode (press menu and –vol and switch on with the remote control) and entered the VG2 set-up that I saw "error" next to it. Adjusting the screen control of the flyback transformer changed this message from "increase" to "OK" to "decrease". Leaving it on "OK" finally removed the "Child Security Active" message.

It's easy once you know why and how!

An expensive repair

A dead Sony KV-PF21L70 (BG-3S chassis) was brought in and I immediately thought "piece of cake".

Its line output transistor (Q511, 2SD2578-CA) was short circuit. I replaced it, resoldered the line drive transformer (T501) to eliminate any potential dry joints and checked C528 which is across transistor Q511. I then switched the set on, thinking that that would be the end of the matter.

So much for my confidence – the new (and rather expensive) transistor failed again and I was back to square one!

This time, I removed the flyback transformer (T503) and checked it with a shorted turns tester. It checked OK but just to be sure, I substituted a flyback transformer from a similar set with a broken tube. I then shorted out the base and emitter terminals of the line output transistor and hung a 60W globe on its collector, along with a DVM.

When I applied power, the globe lit and the DVM measured +135V. I then touched the CRO probe on the collector of line driver transistor Q506 and momentarily saw a good waveform appear.

Suitably encouraged, I removed the globe and the base-emitter short from the line output transistor, attached the CRO probe to its collector and set the DVM for maximum hold on the 135V rail. Once again, the set tried to fire up but after an initial rush of static, it immediately died. The second replacement transistor had also failed.

Both the waveform and voltage were correct, so I checked for shorts on the secondary of the flyback transformer, replaced the transistor again and tried another deflection yoke. This third transistor also failed when power was applied.

By now I was beginning to feel that excessive EHT was killing these expensive transistors. I had already used up my entire stock, so I switched temporarily to cheaper BU2508DF transistor equivalents.

Unfortunately, the failed start-ups were also causing further damage. D504 and Q505 (an IRF614 FET in the east-west circuit) had gone short circuit and IC301 CXA21395 jungle had also been damaged. This latter IC is extremely expensive, costing just over $110.

Even worse, I still I hadn't got within cooee of solving this but my pride wouldn't let me stop. As a last-ditch effort, I started removing and checking all the capacitors in Q511's collector circuit. Fortunately, the third one I checked, C538 (8.5nF), was faulty, measuring just 1nF. This is a critical capacitor and as the EHT is inversely proportional to its value, it's a wonder the tube hadn't been damaged by flashover.

I fitted a new capacitor and switched on with some trepidation. This time the picture and sound came on perfectly. However, I wasn't completely out of the woods because there was still one more fault.

On high-contrast pictures (ie, high beam current), the picture would pull to the left and the set would switch off with the red LED flashing twice, denoting overcurrent protection. The self-diagnosis showed errors 002, 003 and 004 as all being 001.

I spent a lot of time analysing and measuring the ABL (Automatic Brightness Limiter) circuit, especially D315, D316 and Q312, before finally concluding there was nothing wrong with it. Eventually, I realised that it was a protection fault and that Q604 and Q503 were being switched on.

It was then that the penny dropped – R615 (1.2Ω) had gone high due to the repeated excessive current being drawn by the short-circuit horizontal output transistors. I replaced it and this time the set performed correctly – but was this all really worth it?

Oh, well – you win some and you lose some. SC

siliconchip.com.au

PRODUCT SHOWCASE

Programming bigger PICs?

SILICON CHIP published a Portable PIC Programmer back in September 2003 and it continues to enjoy popularity. However, it is limited to 18-pin PICs.

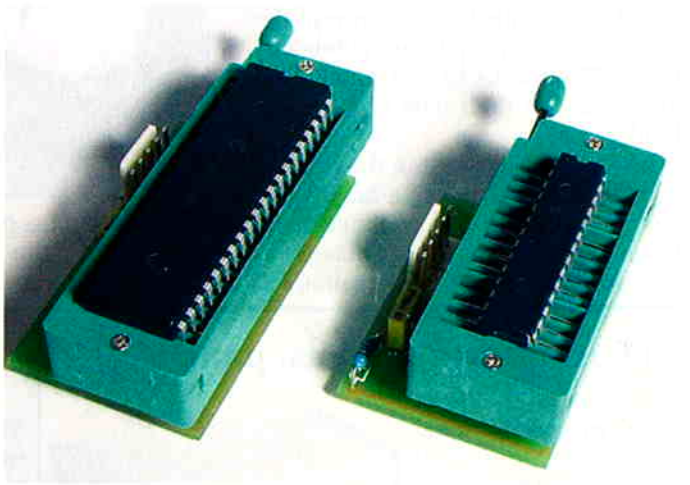
What if you want to program a 28-pin or 40-pin device such as the larger PICs now becoming quite common? We described a small circuit in the article which showed you how but Altronics' Cameron Costigan has taken this one step further by designing two separate add-on boards based around Peter Smith's original Portable PIC Programmer design.

Both kits retail for $24.95 and include a bonus PIC chip. The 28-pin kit (K9506) includes a Pic16F767 while the 40-pin kit (K9507) has a Pic16F877. Each board has a universal Zero-Insertion-Force (ZIF) socket, which means that you can program both narrow and wide-spacing PICs.

The Altronics Portable PIC Programmer Kit (K9505) itself includes a fully pre-made DB9 cable, 18-pin ZIF socket and a Pic16F84A.

Construction is very straightforward as there are only four parts to solder to the PC board.

For this month only, you can get all three kits (the original Portable PIC Programmer and both add-on kits) for $79.95, a total saving of almost $30.00.



Contact:
Altronics Distributors
Box 8350, Perth Business Centre 6849
Tel: 1300 797 007 **Fax:** (08) 9428 2187
Website: www.altronics.com.au

Melbourne PICAXE fair

Following the success of the Sydney PICAXE fair, Microzed's Bob Nichol has decided it's time for Melbourne to have a go. The Melbourne PICAXE fair will be held at Victoria University, Ballarat Rd, Sunshine on Saturday, April 30th from 10AM to 4PM.

"While I was very happy with the attendance at the Sydney fair, a lot of people said that they couldn't make it on a weekday," said Bob. "So the Melbourne fair will be on a Saturday."

Microzed expects a similar range of trade suppliers to exhibit at the Melbourne fair, along with more than a few PICAXE specialists.

Anyone with a PICAXE project is invited to bring it along, even if it is unfinished, and show it off. There is a prize for the best PICAXE project.

At time of going to press, "Mr PICAXE", Stan Swan, from Massey University in NZ, was trying to adjust his impossible schedule to allow him to come to Melbourne.

Contact:
MicroZed
PO Box 634, Armidale NSW 2350
Tel: (02) 6772 2777 **Fax:** (02) 6772 8987
Website: www.microzed.com.au

Text/graphics on VGA monitor – without a PC

To display text and graphics on a VGA monitor you need a PC with a video card, correct?

Until now, yes. But there are many applications where you want the text and graphics but don't want to lug a PC around to drive it.

4D Systems has come up with rather clever module called MicroVGA which enables text and an unlimited variety of graphics to be generated from a host microcontroller or embedded device with RS-232 output. Of course, this also includes the vast majority of PCs. The baud rate is auto-detected.

The signal generating circuitry can output in up to 64 colours, setting not only text and graphics colours but also the screen background colours. You can address the full ASCII character set. Once set up, there is no need for the source to remain connected.

Typical applications include a wide variety of consumer display and information systems, process and industrial control systems; in fact just about anything where text and graphics need to be delivered. Contact 4D Systems for more information or a PDF of the manual.

Contact:
4D Systems
Tel: (02) 9673-2228 or 0433 198 874
email: atilla@4dsystems.com.au

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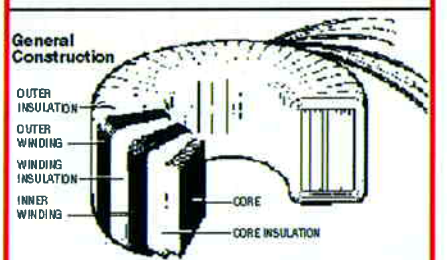

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Jaycar's WiFi Spy finds hotspots, hidden cameras

There are huge numbers of WiFi hotspots (802.11 wireless LANs) around these days and finding them is often as simple as walking around with your notebook computer searching for wireless LAN activity . . .

But who wants to walk around the streets carrying an open notebook? Jaycar Electronics have a much simpler way with their new WiFi-N-Spy Finder.

It's tiny enough to fit in the palm of your hand (it even has a lanyard so you can wear it around your neck) and when it finds either a WiFi hotspot or RF-equipped surveillance camera it lights up and beeps.

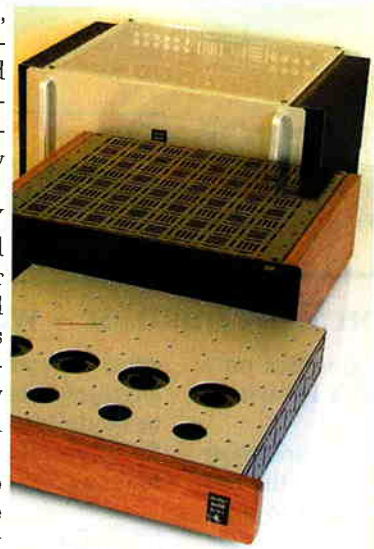
Of course, the WiFi-N-Spy can't tell you any more than the fact that there is a hotspot/camera present but you can then decide if you want to further investigate the source (eg, to determine if is open access or WEP, etc encrypted) by opening the computer and searching it out.

The WiFi-N-Spy retails for $39.95 (Cat XC4885) and is available from all Jaycar Electronics stores, resellers or through their web techstore.

Contact:
Jaycar Electronics
PO Box 6424, Silverwater NSW 1811.
Tel: 1800 022 888 **Fax:** (02) 9741 8500
Website: www.jaycar.com.au

DIY Amplifier chassis, panels

Design Build Listen, the Kiwi makers of ez-Chassis pre-punched cabinets for DIY amplifier builders, have announced a raft of new cosmetic options.



These will help DIY enthusiasts to build the amplifiers of their dreams. Moving beyond "any colour you like as long as it's black" ez-Chassis panels are now available in anodised silver or gold.

Wood panels are also offered for front or side panels, supplied ready for oiling or staining.

Finally for the DIY enthusiast who is proud of their handiwork, clear acrylic top panels are available.

Contact:
Design Build Listen
PO Box 5415, Dunedin, New Zealand
Tel/Fax: +643 477 3817
Website: www.designbuildlisten.com

First BTX form-factor PC released

Hallmark Computer International Pty Ltd has released of Viewmaster Advantage 6000 Series, a high-performance desktop computer claimed to be the first to take advantage of Intel's latest Balanced Technology Extended (BTX) design concept.

The BTX design concept greatly improves the cooling efficiency and significantly reduces the noise of the entire system.

The user of today wants a faster and faster machine in a smaller and smaller chassis. In reality, this causes a higher and higher thermal envelope, which ultimately results in premature failure of components.

Acoustically, a typical classroom is rated at 45dBA; a quite office at 40dBA. Given that a decrease of 3dBA means that the volume has halved, the 30dBA approximate level produced by the Viewmaster Advantage 6000 series BTX system equates to about a 90% noise reduction of the quietest office.

BTX aligns the hottest components – CPU, chipset and graphics controller such that they are cooled by the front-to-back airflow produced by a single large, slow RPM fan that also acts as the CPU fan.

The result is a design which no longer requires multiple chipset, graphics card and chassis fans.

Contact:
Hallmark Computer International
PO Box 5415, Dunedin, New Zealand
Tel/Fax: +643 477 3817
Website: www.hallmark.com.au

SILICON CHIP WebLINK

How many times have you wanted to access a company's website but cannot remember their site name? Here's an exciting new concept from SILICON CHIP: you can access any of these organisations instantly by going to the SILICON CHIP website (siliconchip.com.au), clicking on **WebLINK** and then on the website graphic of the company you're looking for. It's that simple.

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Compact wind speed and direction display

A new wind speed and direction display from Amalgamated Instrument Co Pty Ltd (AIC) shows wind direction is on a circular LED display, while wind speed, scaled to desired units (m/s, km/h, knots, etc) is indicated in a 5-digit LED numerical display.

The entire unit is housed in a 1/8 DIN panel mount enclosure (bezel size 96mm x 48mm) with IP65 environmental protection options available.

Wind sensor input can be in either a 4-20mA format or NEMA serial data stream.

Wind direction can be displayed as degrees on the numerical display as well, at the push of a button.

The display includes alarm annunciators for quick warning of "out of line" situations.

This unit is ideal for applications where an accurate, easily visible display is required and where space is at a premium.

Contact:
Amalgamated Instrument Coy P/L
5/28 Leighton Pl, Hornsby NSW 2077
Tel: (02) 9476 2244 **Fax:** (02) 9475 2902
Website: www.aicpl.com.au

Ah! Three into one does go!

With a home theatre setup or even a reasonable selection of video/audio devices and games, it seems that you are always plugging and unplugging leads these days to watch/listen to what you want!

This A/V switch box from Microgram can switch three different devices (3 in, 1 out) with lots of connectors including optical audio, so its perfect for switching between DVD's, satellite receivers, pay TV, games consoles, CD's and other digital audio/video equipment.

It is really well built and has a remote control, so you can switch programs from your armchair!

Each channel has S-VHS, composite, audio and optical audio inputs to a single output also with S-VHS, composite and optical audio. Recommended retail price is $149.00

Contact:
Microgram Computers
1/14 Bon Mace Cl, Berkeley Vale 2261
Tel: (02) 4389 8444 **Fax:** (02) 4389 8388
Website: www.microgram.com.au

Greener chips from Linear Technology

Linear Technology Corporation, a leading supplier of high performance analog integrated circuits, has announced that all of the company's products are available in lead-free versions as an ordering option.

This is part of the company's commitment to meeting the European Community's Reduction of Hazardous Substances (RoHS) guidelines and represents the latest step in Linear Technology's ongoing commitment to excellence and leadership in protecting the environment.

After evaluating various lead-free alternatives, Linear Technology selected matte tin as the optimal plating for lead-free products. The company believes that this provides the best drop-in replacement since it has the lowest reflow temperature of the lead-free alternatives, has excellent solderability performance and provides excellent quality and reliability.

In order to ensure a smooth transition for customers, Linear Technology will continue to offer solder-plated products as well, with unique part numbers for both the lead-free and solder-plated versions.

In addition to offering lead-free plating, Linear Technology will also provide by mid-2005 an improved plastic mold compound that eliminates antimony trioxide and elemental bromine for a more environmentally-friendly packaging alternative. The company's goal is to replace these flame retardants with environmentally friendly alternatives that meet flammability standards, while improving the product reliability.

Contact (Australian agents):
Soanar Inc (Mayer Krieg Components)
D1, 3-9 Birney Ave, Lidcombe NSW 2141
Tel: (1300) 889 883 **Fax:** (02) 9741 0155
Website: www.linear.com

JED designs and manufactures a range of single board computers (based on Wilke Tiger and Atmel AVR), as well as LCD displays and analog and digital I/O for PCs and controllers. JED also makes a PC PROM programmer and RS232/RS485 converters.

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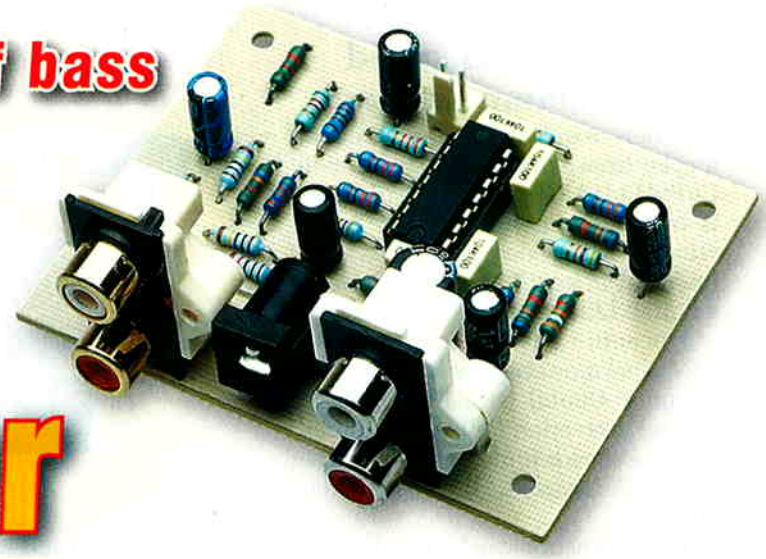


This Bass Extender circuit can give you as much as an extra octave of bass response from your existing hifi speakers, as long as you are not running them near full power.

Design by RICK WALTERS

THIS MAY SOUND like black magic. Just how is it possible to get an extra octave of bass response from a hifi loudspeaker? Well, the theory supporting this idea originates from Neville Thiele's 1961 paper (1) on loudspeakers and vented enclosures. He postulated that the response of a loudspeaker in a vented enclosure was similar to a fourth-order high-pass filter, rolling off in the bass region at -24dB per octave. For a sealed enclosure, the response was similar to a second order high-pass filter, rolling off at -12dB per octave.

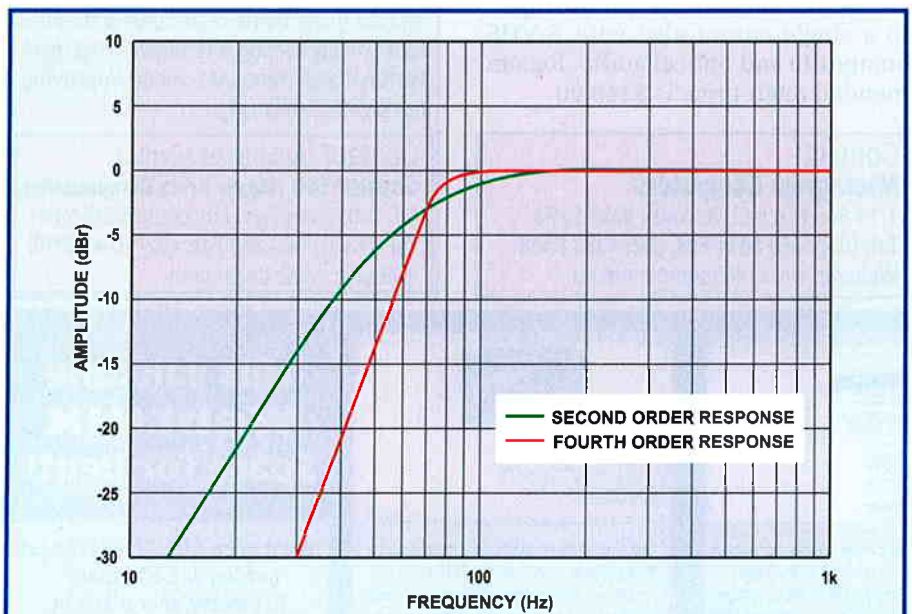


Fig.1: the response in a vented enclosure is similar to a fourth-order high-pass filter, rolling off in the bass region at -24dB per octave (red trace). Similarly, the response in a sealed enclosure rolls off at -12dB per octave (green trace), much like a second-order filter. This graph plots the response of hypothetical speakers with a cutoff frequency of 70Hz.

Fig.1 shows this for hypothetical speakers that are -3dB down at 70Hz (the cutoff frequency), in each type of enclosure. Now if we apply bass boost with an amplitude of +3dB at 70Hz, rising to a maximum boost of around 11dB or so (for a sealed enclosure), it will partially compensate for the speaker's rolloff and thus extend the bass response by as much as an octave.

As we'll see later, the Bass Extender can be tailored for either type of enclosure, applying less boost to a vented enclosure than a sealed enclosure. This is the opposite of what you might expect but is necessary because the speaker cone in a vented enclosure has little loading below the box resonance.

There is a limit to the amount of bass compensation we can apply anyway. A speaker's cone excursion increases as frequency decreases, so large bass boost levels would test the mechanics of the speaker as well as the damping ability of the enclosure. Also, it is likely that some power amplifiers would run into clipping.

Even with all these limitations, we can usually gain an extra octave without major problems. This is much more precise than merely boosting the bass with your amplifier's tone controls, as it's compensating for the loudspeaker's natural rolloff.

Note this does not mean that the overall bass from the speaker will increase for all music. Since the bass response will be extended to a lower

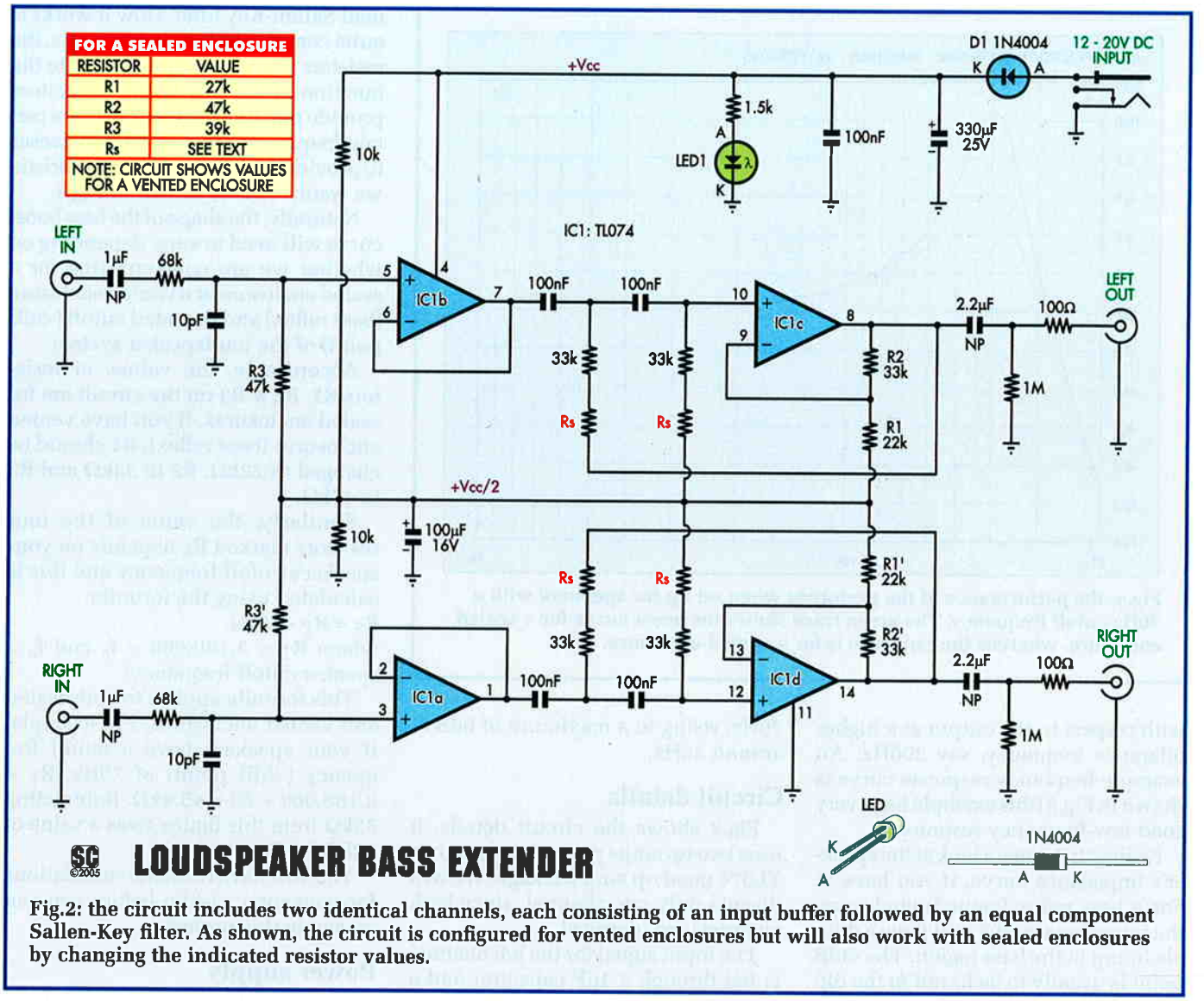


Fig.2: the circuit includes two identical channels, each consisting of an input buffer followed by an equal component Sallen-Key filter. As shown, the circuit is configured for vented enclosures but will also work with sealed enclosures by changing the indicated resistor values.

frequency (say, 35Hz instead of 70Hz) you will only hear the difference if the music signal includes bass content at these low frequencies. Incidentally, if your loudspeakers have a response down to 50Hz or better, there is no point in building the Bass Extender.

Speaker specifics

The catch in this process is that you need to know the rated cutoff frequency for your speakers. Once you know this, you need to calculate a particular resistor value for the bass boost circuit. Apart from that, the circuit is simple and foolproof.

So, what is the rated cutoff frequency for your hifi loudspeakers? If you have the manufacturer's original specs, it is easy. They should give a frequency response curve and you just look to see where the bass response is 3dB down

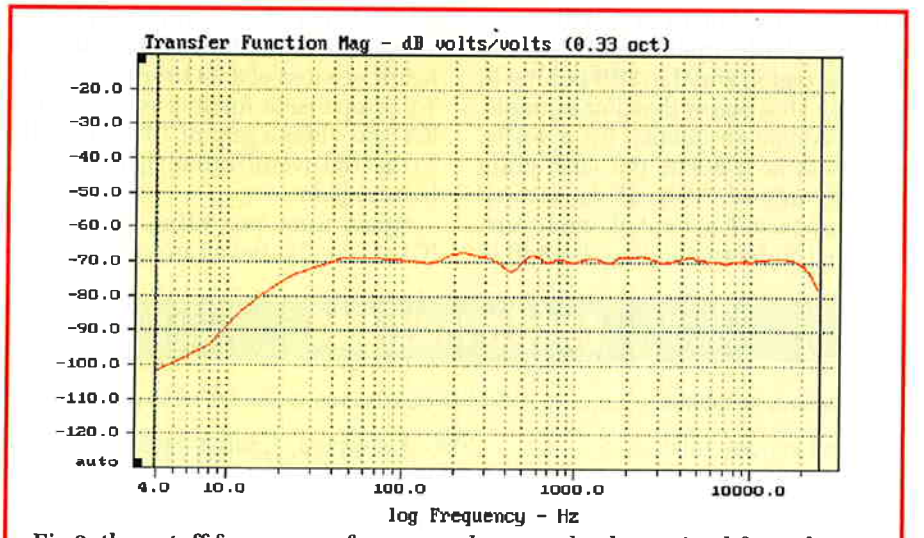


Fig.3: the cutoff frequency of your speakers can be determined from the manufacturer's data sheets. Here, the frequency response curve from a VAF DC-7 G4 shows a -3db point around 25Hz. In this case, there is absolutely no point in building the Bass Extender!

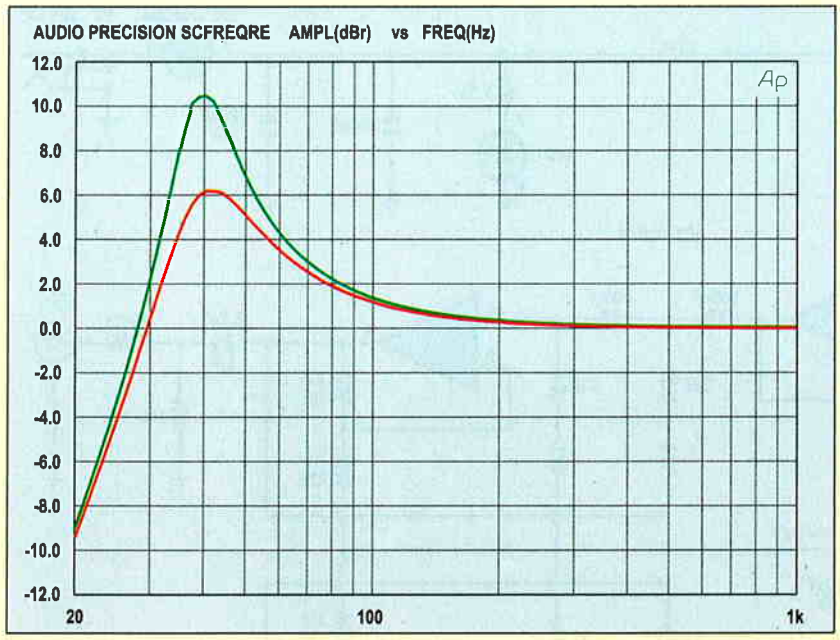


Fig.4: the performance of the prototype when set up for speakers with a 70Hz cutoff frequency. The green trace shows the boost curve for a sealed enclosure, whereas the red trace is for a vented enclosure.

with respect to the output at a higher reference frequency, say 200Hz. An example frequency response curve is shown in Fig.3 (this example has a very good low-frequency response).

Failing that, have a look at the speaker's impedance curve, if you have it. For a bass reflex (vented) enclosure, the impedance curve will have a double hump in the bass region. The -3dB point is usually to be found in the dip between the two humps.

Similarly, if you have a sealed enclosure, the impedance curve will have a single peak (the system resonance) in the bass region and the -3dB point will be about 10% below that. For example, if the system resonance for a sealed enclosure is at 80Hz, the -3dB point will be around 70Hz. If we wanted to compensate a vented enclosure, we need to boost the bass by 3dB at 70Hz, rising to a maximum of 6dB at around 35Hz.

Circuit details

Fig.2 shows the circuit details. It uses two op amps per channel, all in a TL074 quad op amp package. We will discuss only one channel, since both channels are identical.

The input signal for the left channel is fed through a 1µF capacitor and a resistive attenuator to the non-inverting input (pin 5) of op amp IC1a, which is wired as a unity gain buffer. The 68kΩ and 39kΩ resistors at pin 5 result in a loss of 2.74 times (-8.76dB). To compensate for this loss, op amp IC1c provides a gain of 2.74 (+8.76dB) so that the overall circuit gain is unity; ie, zero gain.

Apart from providing some gain, IC1c is configured as an equal component Sallen-Key filter. How it works is quite complex but in simple terms, the resistors from the output (pin 8) to the junction of the two 100nF capacitors provide positive feedback below a certain frequency. Thus the gain increases to provide the bass boost characteristic we want. This is shown in Fig.4.

Naturally, the shape of the bass boost curve will need to vary, depending on whether we are compensating for a sealed enclosure or a vented enclosure (bass reflex) and the rated cutoff (-3dB point) of the loudspeaker system.

Accordingly, the values of resistors R1, R2 & R3 on the circuit are for sealed enclosures. If you have vented enclosures (bass reflex), R1 should be changed to 22kΩ, R2 to 33kΩ and R3 to 47kΩ.

Similarly, the value of the four resistors marked R_S depends on your speaker's cutoff frequency and this is calculated using the formula:

$R_S = R_T - 33k\Omega$

where $R_T = 3{,}180{,}000 \div f_c$ and f_c = speaker cutoff frequency.

This formula applies to both sealed and vented enclosures. For example, if your speakers have a cutoff frequency (-3dB point) of 70Hz, R_T = 3,180,000 ÷ 70 = 45.4kΩ. Subtracting 33kΩ from this figure gives a value of 12kΩ for R_S.

You will have to do the calculations for your own system before you can assemble this project.

Power supply

The circuit can be powered from 12-20V DC. Diode D1 provides input polarity protection.

Two 10kΩ resistors divide the supply rail in half ($V_{CC}/2$). This is used as a bias voltage for IC1, necessary to allow the op amp to work with AC signals when running from a single supply rail.

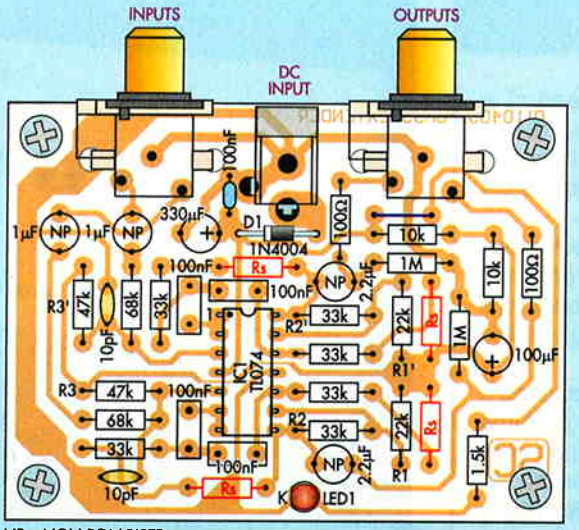
Provision has been made for a power indicator (LED1) but we expect that most readers will not install this. It should not be installed if the board is to be powered from a DC plugpack, as the extra current drain will increase supply hum.

Construction

All parts for the Bass Extender mount on a small PC board, measuring 74 x 56mm (code 01104051). As usual, begin by checking the PC board for defects. Now is also a good time to enlarge the mounting holes for the

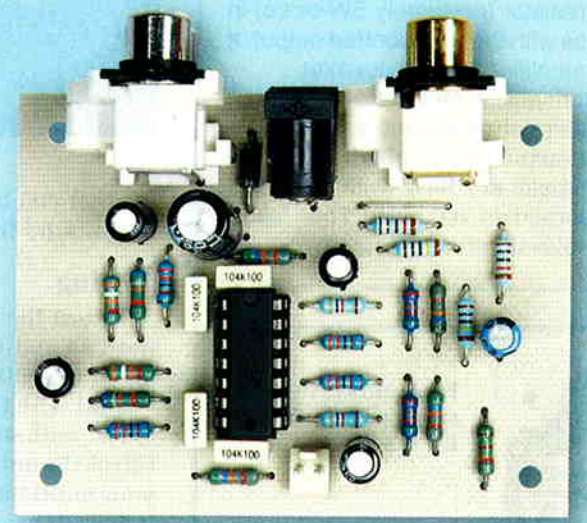
SPECIFICATIONS

Frequency response	-3dB @ 61kHz (see graph for bass response)
Signal to noise ratio	-70dB unweighted, -83dB A-weighted (with respect to 1V, 20Hz - 20kHz bandwidth)
Total harmonic distortion	0.02% at 1kHz and 20kHz (1V input)
Signal handling	2.5V RMS maximum input level (12V DC supply)
Crosstalk	60dB (typical)



NP = NON-POLARISED

Fig.5: use this diagram as a guide during assembly. Take care with the orientation of the diode (D1), op amp (IC1) and the 100µF & 330µF capacitors. The 1µF & 2.2µF capacitors are non-polarised and can go in either way.



Right: this view shows the prototype PC board assembly. Note that there are some minor differences between this prototype and the final version shown in Fig.5 above.

Parts List

1 PC board, code 01104051, 74 x 56mm
1 UB3 size plastic case (Jaycar HB-6013 or similar) (optional)
2 dual PC-mount RCA sockets
1 2.1 or 2.5mm PC-mount DC socket
2 6G x 6mm self-tapping screws for RCA sockets
1 16-pin IC socket

Semiconductors
1 TL074 op amp (IC1)
1 3mm or 5mm red LED (optional; see text)
1 1N4004 diode (D1)

Capacitors
1 330µF 25V PC electrolytic
1 100µF 16V PC electrolytic
2 1µF 16V non-polarised PC electrolytic
2 2.2µF 16V non-polarised PC electrolytic
4 100nF 50V metallised polyester (MKT)
1 100nF 50V monolithic ceramic
2 10pF 50V disc ceramic

Resistors (0.25W 1%)

2 1MΩ	2 27kΩ
2 68kΩ	2 22kΩ
2 47kΩ	2 10kΩ
2 39kΩ	1 1.5kΩ
6 33kΩ	2 100Ω

RCA sockets and/or power socket, if required.

Next, install the single wire link, diode (D1) and all of the resistors, using the overlay diagram (Fig.5) as a guide. It's a good idea to check resistor values with a multimeter before installation. Note that the banded (cathode) end of the diode must be oriented as shown.

Follow up with the IC socket and all of the capacitors. The larger 100µF and 330µF electrolytic capacitors are polarised and must be inserted with their positive leads oriented as indicated by the "+" markings on the overlay.

The two RCA sockets and power socket can be left until last. Push them all the way down on the PC board before soldering them in position. That done, plug in the TL074 (IC1), watch-

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	1MΩ	brown black green brown	brown black black yellow brown
❑	2	68kΩ	blue grey orange brown	blue grey black red brown
❑	2	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	2	39kΩ	orange white orange brown	orange white black red brown
❑	6	33kΩ	orange orange orange brown	orange orange black red brown
❑	2	27kΩ	red violet orange brown	red violet black red brown
❑	2	22kΩ	red red orange brown	red red black red brown
❑	2	10kΩ	brown black orange brown	brown black black red brown
❑	1	1.5kΩ	brown green red brown	brown green black brown brown
❑	2	100Ω	brown black brown brown	brown black black black brown

DIY Loudspeaker Measurements

How do you measure your speaker's resonance in its enclosure? For both types of enclosures, you will need an audio oscillator, an analog multimeter, AC millivoltmeter or oscilloscope and a 47Ω resistor. A frequency counter can be used to set your oscillator's output if it lacks an accurately calibrated scale.

Bass reflex (ie, with a vent): connect the oscillator's output to the speaker terminals, running one of the connections via the 47Ω resistor. That done, monitor the voltage across the speaker terminals (set your meter to its lowest AC range) and slowly reduce the oscillator frequency, starting off at about 200Hz. The reading should rise to a maximum then fall then rise again. The middle of the dip is the resonant frequency of the speaker and enclosure combination.

Sealed (closed box or infinite baffle): the same setup is used as for a bass reflex design but instead of a dip between two peaks, your meter should rise to a maximum then fall. The peak is the resonant frequency of the system.

In most cases, the system resonance will be near your speaker's free-air resonance but can be a little higher or lower depending on the enclosure size.

If you cannot get a reasonable reading on your multimeter, perhaps due to the low output level from your oscillator, you will have to feed the oscillator into an audio amplifier. Place the resistor (preferably 5W or so) in series with the ungrounded output of the amplifier and the speaker.

Connect the multimeter across the speaker terminals and set the oscillator output to give about 1V on the multimeter at 200Hz (with the amplifier turned on, naturally). Then follow the relevant procedure above.

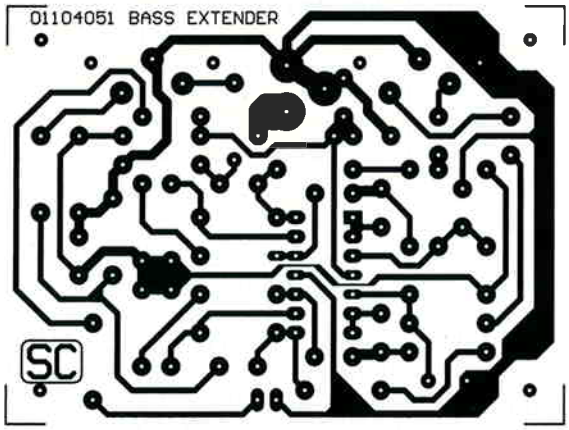


Fig.6: this is the full size etching pattern for the PC board.

ing that you have the notched (pin 1) end around the right way.

Testing

To test the Bass Extender you will need an audio oscillator and a multimeter or oscilloscope.

Start with the oscillator set to about 1kHz, with 450-500mV RMS output. Check the output of the oscillator with your multimeter (or millivoltmeter) if it doesn't have a calibrated amplitude scale.

Apply power and connect the oscillator to the left and right RCA inputs in turn. Measure the amplitude of the signals at the corresponding RCA outputs; they should be almost identical to the inputs.

Now set the oscillator to your speaker's resonant frequency; eg, 80Hz.

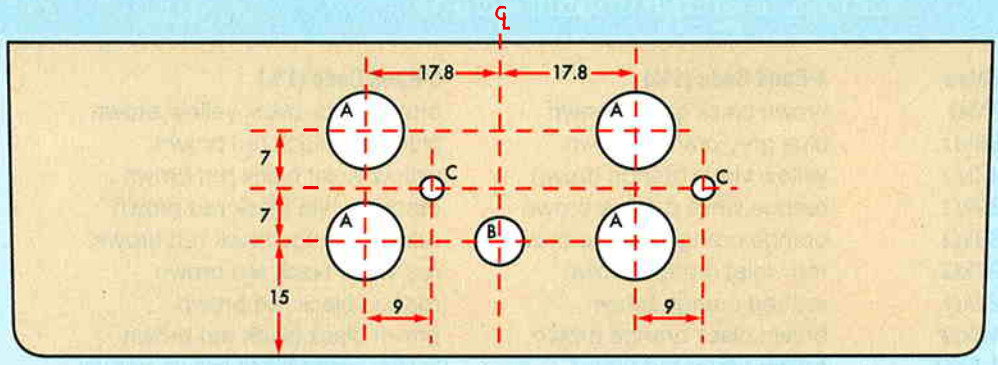
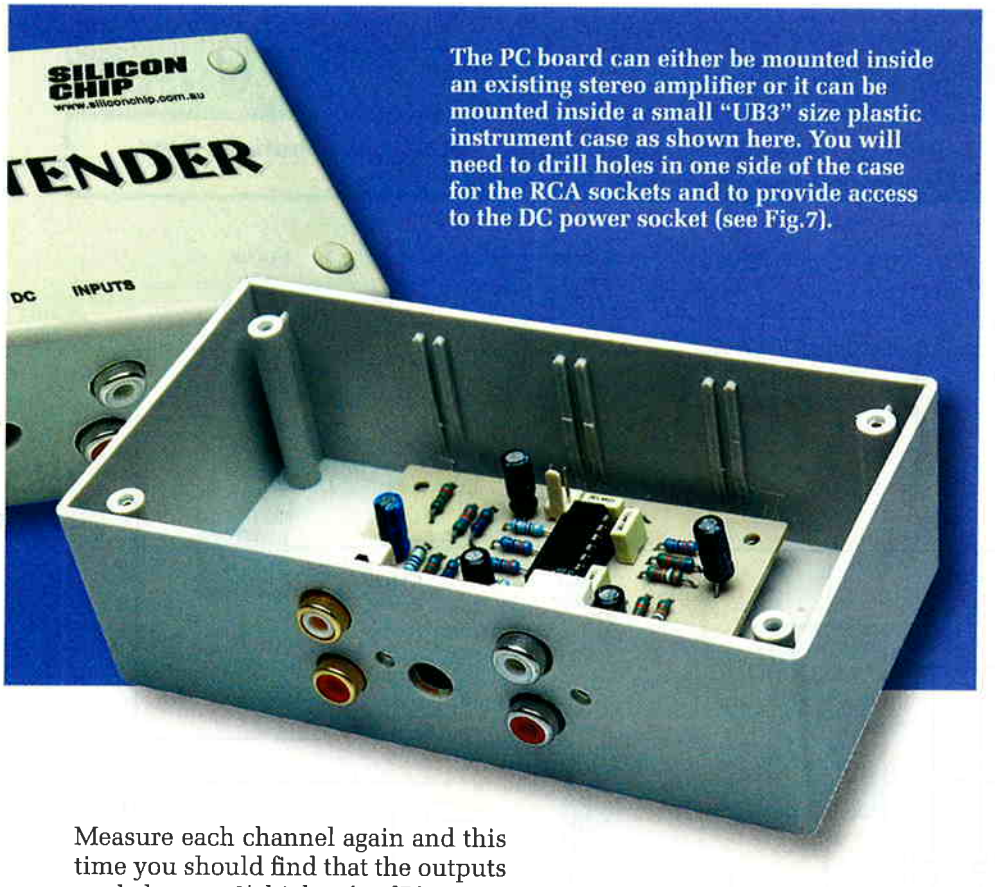


Fig.7: if you're installing your board into a case, a photocopy of this drilling guide will make life much easier.



The PC board can either be mounted inside an existing stereo amplifier or it can be mounted inside a small "UB3" size plastic instrument case as shown here. You will need to drill holes in one side of the case for the RCA sockets and to provide access to the DC power socket (see Fig.7).

Measure each channel again and this time you should find that the outputs read about 40% higher (+3dB).

Finally, measure each channel while tweaking the oscillator frequency to obtain the maximum possible reading. For a bass reflex (vented) enclosure, the maximum output should be around twice the input (+6dB), while for a sealed enclosure it should be about 3.5 times higher (+11dB), in line with the performance of our prototype (see Fig.4).

If the results aren't what you expect, then go back and re-check your resistor calculations. If you don't get any bass boost, it is likely that the value calculated for R_S is much too large.

For those without the appropriate test gear, a listening test will quickly tell whether the Bass Extender is doing its job. Simply hook the project into one channel of your hifi system and listen to the bass with a suitable music program; the difference between channels should be noticeable.

Housing

The Bass Extender could be used in a variety of ways. For example, it could be installed inside a stereo amplifier and patched into a tape loop or inserted between the preamp and power amplifier stages. It could also be used in a car sound system.

Where a separate enclosure is required, the board can be installed inside a small "UB3" size plastic instrument case. Mounting details for this option are as follows:

Photocopy the drilling template (Fig. 7) and place it centrally along the open edge of the plastic case, fixing it in place with adhesive tape. Mark and drill the holes, starting with small pilot holes and working up to the final size in several steps. A tapered reamer can also be used to enlarge the holes.

The three ribs on the inside of the case should be removed with a sharp knife or chisel to allow the power socket to fit flush with the inside. The bottom 5mm or so of the three ribs on the other side may need to be removed if the board is reluctant to fit.

Drop the PC board into the case and then slide the board backwards. The sockets will drop into their holes and the two self-tapping screws can then be fitted to hold the RCA sockets and PC board in place.

References

(1). A. Neville Thiele, "Loudspeakers in Vented Boxes," Proceedings of the IRE Australia, August 1961; reprinted Journal of Audio Engineering Society, May & June 1971. SC

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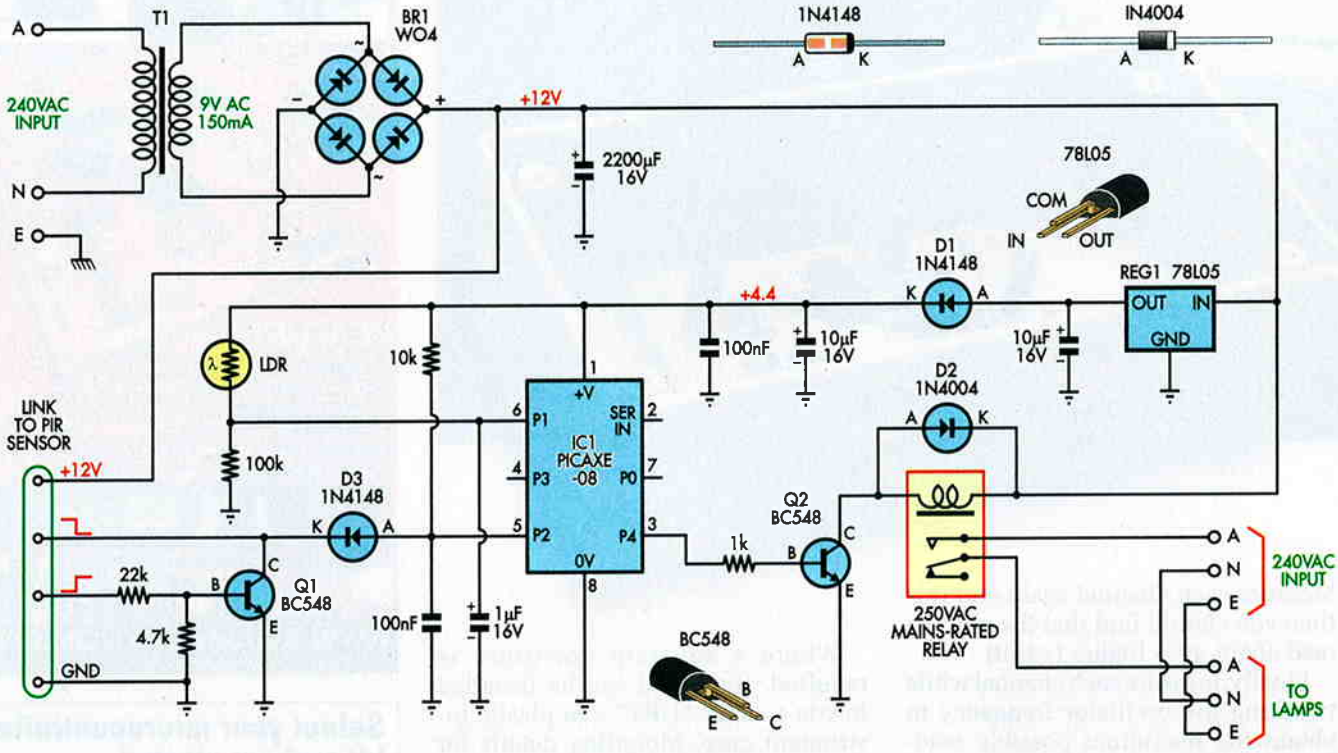
CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions from readers are welcome and will be paid for at standard rates.



Automatic security lights

Combination PIR sensor and floodlight units are cheap but rather inflexible if you want to locate the sensor and light in different places. In my case, I wanted to detect movement on the driveway and switch on the lights in the carport around the corner. Yet another job for the ubiquitous PICAXE-08 microcontroller!

A standard PIR sensor is used as the movement detector. The sensor interfaces to the PICAXE (IC1) on input 2 (pin 5). This pin is pulled low via isolation diode D3 and the normally open (NO) output of the sensor whenever movement is detected. It can also be pulled low by transistor Q1, which acts as a simple inverter for sensors with normally closed (NC) outputs.

So that the lights aren't needlessly switched on during the day, a light-dependent resistor (LDR) is used as an ambient light sensor. Together with a 100kΩ resistor, the LDR forms a simple voltage divider, which converts its changing resistance to a changing voltage at the micro's analog input (pin 6). As light falling on the sensor decreases, its resistance increases, resulting in less voltage at the analog input. Below a preprogrammed threshold voltage, it is assumed to be nighttime.

When movement is detected, a program timer is started and the relay is energised via Q2, switching on the lights. If no further movement is detected, the lights will turn off after about 10 minutes. However, if movement is detected within this period, the timer is reset, extending the on period a further 10 minutes.

The on time is easily modified to suit your installation (see program listing).

As shown, power comes from a small 9VAC transformer, bridge rectifier (BR1) and a 2200µF filter capacitor. A 9V DC plugpack could also be used; just omit the transformer and BR1 and substitute a 100µF 25V capacitor for the 2200µF unit. A polarity protection diode (eg, 1N4004) in series with the positive plugpack input is also a good idea.

A 7805 low-power regulator provides a stable +5V supply for the PICAXE and associated circuitry. Note that a diode (D2) is included in series with the regulator output to reduce the supply voltage to about 4.4V, which improved system reliability in hot weather.

All 240VAC wiring should be properly terminated and insulated, and the project housed in a suitable plastic instrument case that is protected from the elements. Modifications to fixed mains wiring will require the services of a licensed electrician.

Jeff Monegal,
North Maclean, Qld. ($50)

```
' Security Lights Controller
' Jeff Monegal  18 May 2004

' PICAXE-08

symbol timer = w6                    'used as a lights on timer

'-------------------------------------------------------------------------------
' The value in the B0 register from the readadc command below may need to be
' changed to suit different types of LDR. Use the debug command to monitor
' the value given by your particular LDR. Don't forget to change the rest of
' the readadc values throughout the program.
'-------------------------------------------------------------------------------

start:
  readadc 1,b0                       'read the LDR
  debug b0                           'look at the value given by your LDR
  if b0 < 140 then night_time        'if less than 140 then it is night time
  goto start

night_time:
  if input2 = 0 then detect
  readadc 1,b0
  if b0 > 140 then maybe_daytime
  goto night_time

detect:
  pause 100                          'short delay then look at the PIR again to confirm
  if input2 = 0 then yes_detect 'a movement detection and not just noise
  goto night_time

yes_detect:
  timer = 0                          'clear timer counter
  high 4                             'turn on the lights

time_loop:
  readadc 1,b0
  if b0 > 140 then maybe_daytime
  timer = timer + 1                  'add one to the time counter
  if timer > 3000 then time_out      'change to suit your installation
  pause 100                          '(3000 x 200mS = 600s)
  if input2 = 1 then time_loop
  pause 100                          'short delay then look again for movement
  if input2 = 1 then time_loop
  timer = 0                          'reset timer if movement detected
  goto time_loop

time_out:
  low 4                              'turn the lights off
  pause 3000                         '3s before lights can be triggered again
  goto night_time

maybe_daytime:
  pause 2000
  readadc 1,b0
  if b0 > 140 then is_daytime
  goto night_time

is_daytime:
  low 4                              'turn lights off in case they are on
  goto start
```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Op amp auto-zero

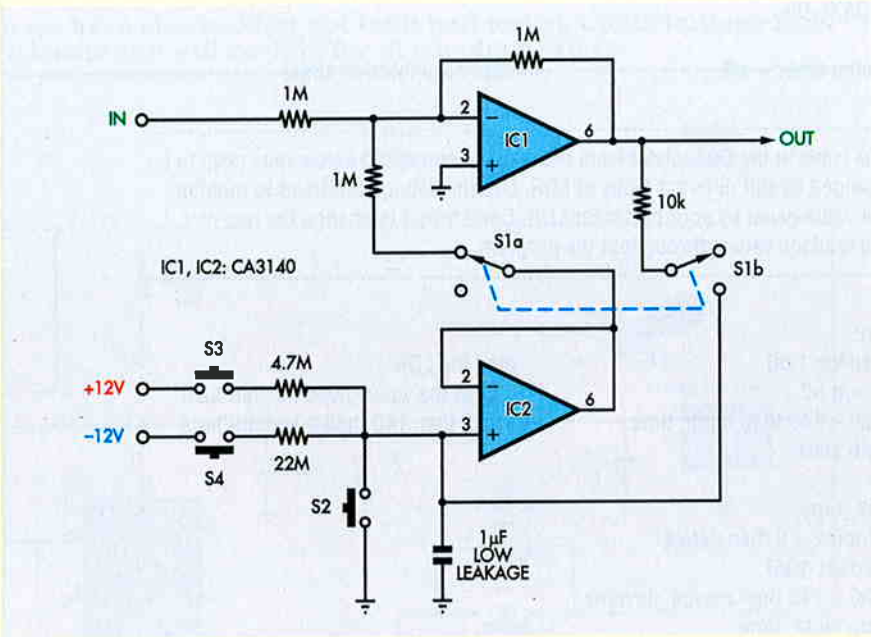
This auto-zero circuit was developed to simplify setting up an instrument with a large background signal that needed to be zeroed out. It uses two CA3140 op amps, which themselves could be trimmed out for a smaller final offset value if required (see device datasheet for more details).

The input signal is applied to IC1, which is configured as an inverting buffer. When momentary switch S1 closes, IC1's output voltage charges the low-leakage 1µF capacitor via the 10kΩ resistor. When S1 subsequently opens, this voltage (buffered by IC2) is subtracted from the input signal to IC1, thus zeroing the output.

If desired, IC1 could be followed by a second stage to restore the original signal polarity.

Switch S2 can be used to discharge the capacitor and cancel the zero. Switches S3 and S4 are included to allow fine adjustment of the output voltage. A smaller resistor (4.7MΩ) in the positive charge circuit versus the negative circuit (22MΩ) allows for finer control. Slower adjustment can be arranged by returning these resistors to a lower voltage.

Graham Jackman, via email. ($30)



Synthetic floating negative inductor

This circuit is a floating negative inductor using only two op amps. It obviates use of a GIC (General Impedance Converter), which would require more than four op amps for the same purpose. It requires two matched capacitors and three matched resistors. The relevant equations are as follows:

(1) $i1 = (V1 - V3)/R$;
(2) $i2 = (V2 - V4)/R$; and
(3) $(V2 - V4).\ Cs = (V3 - V1).\ Cs = (V1 - V2)/R$

From (1), (2) and (3):

(4) $V1 = -i1.\ CsR^2 + V2$
(5) $i1 = -i2$

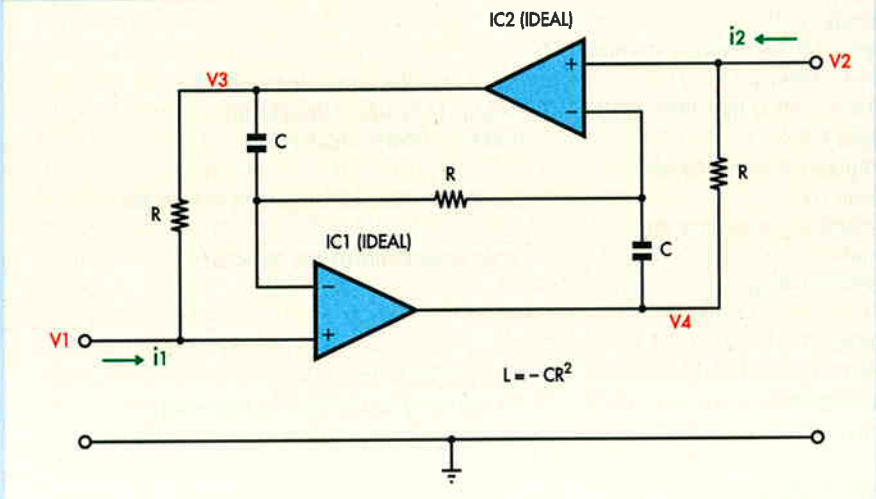
Comparing (4) and (5) with the transmission matrix:

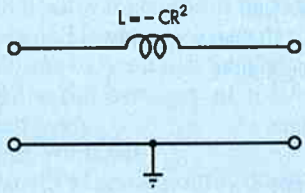
$V1 = A.V2 - B.i2$
$i1 = C.V2 - D.i2$

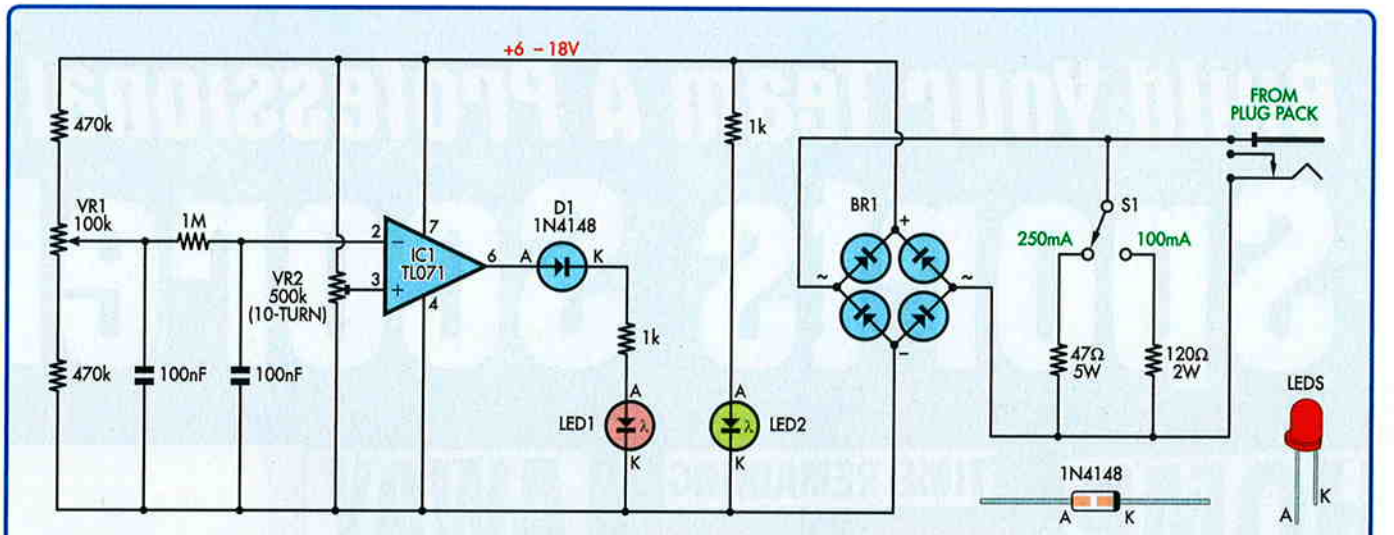
$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 1 & sCR^2 \\ 0 & 1 \end{bmatrix}$$

Now -B is the short circuit transfer impedance, hence equivalent floating impedance is given by $Z = -CR^2$, which is equivalent to a negative inductor.

Saumitra Raj Mehrotra, New Delhi, India. ($30)







Plugpack checker

This simple circuit lets you quickly determine the relative amount of ripple from a DC plugpack. Two test currents are selectable via toggle switch S1. For the 120Ω and 47Ω resistor values shown, this corresponds to 100mA and 250mA of load current when testing 12V plugpacks.

A good-quality 12V plugpack will measure up to about 100mV ripple with a 250mA load. Up to 200mV ripple may be regarded as good, while a budget plugpack may measure up to 500mV. Anything above this can be considered abysmal.

The circuit uses no voltage regulation or supply decoupling to suppress ripple. Therefore, a fraction of the ripple from the power supply appears at the non-inverting input (pin 3) of the op amp (IC1) via the 500kΩ pot (VR1).

In contrast, the voltage at the op amp's inverting input (pin 2) is filtered via two low-pass filters, consisting of the two 470kΩ resistors, 100kΩ potentiometer VR1, a 1MΩ resistor and two 100nF capacitors, which effectively removes most of the ripple.

When the voltage at the inverting input dips below that of the non-inverting input, the op amp's output swings towards the positive rail, illuminating LED1. The 100kΩ potentiometer (VR1) acts as a sensitivity adjustment, allowing you to dial up the amount of ripple present before LED1 illuminates. This makes it possible (with a calibrated dial) to determine just how much ripple a plugpack is generating.

Since the two 100nF filter capacitors are initially discharged, LED1 immediately illuminates when a plugpack is connected, then fades (within two seconds) if the ripple rating is within the selected margin. LED2 provides a simple "voltage present" indication.

IC1 has a limited voltage swing at its output, so D1 is included in series to prevent the LED from glowing when it should be off. Bridge rectifier BR1 ensures that the checker works regardless of input polarity.

Before use, the circuit must be calibrated to suit a particular input voltage. We chose 12V, as most (adjustable) plugpacks have a 12V maximum setting. However, the Plugpack Checker may also be calibrated for use with other voltages between about 5.6V and 18.6V.

Initially, turn VR1 fully anticlockwise (wiper towards 0V) and then connect a 12V battery or other well-regulated (no ripple) 12V DC source. LED2 should illuminate immediately and LED1 may illuminate only briefly, or it may stay illuminated. If it stays illuminated, turn VR2 anti-clockwise (wiper towards 0V) until it just extinguishes, otherwise turn it clockwise until it just illuminates.

With the circuit values shown, you should be able to measure approximately 0-1000mV of ripple. For greater sensitivity but reduced range, the value of VR1 can be scaled downwards. For example, to measure approximately 0-200mV, use a 20kΩ pot instead.

Thomas Scarborough, South Africa. ($40)

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Build Your Team A Professional Sports Scoreb

Because of its modular construction, our new Electronic Scoreboard is easy to build. This month, we describe the assembly of the Control Console and the main control board in the display unit.

IN ALL, THERE are some seven modules to build for the Electronic Scoreboard – two for the control console and five for the main display unit. We'll start with the assembly of the control console modules.

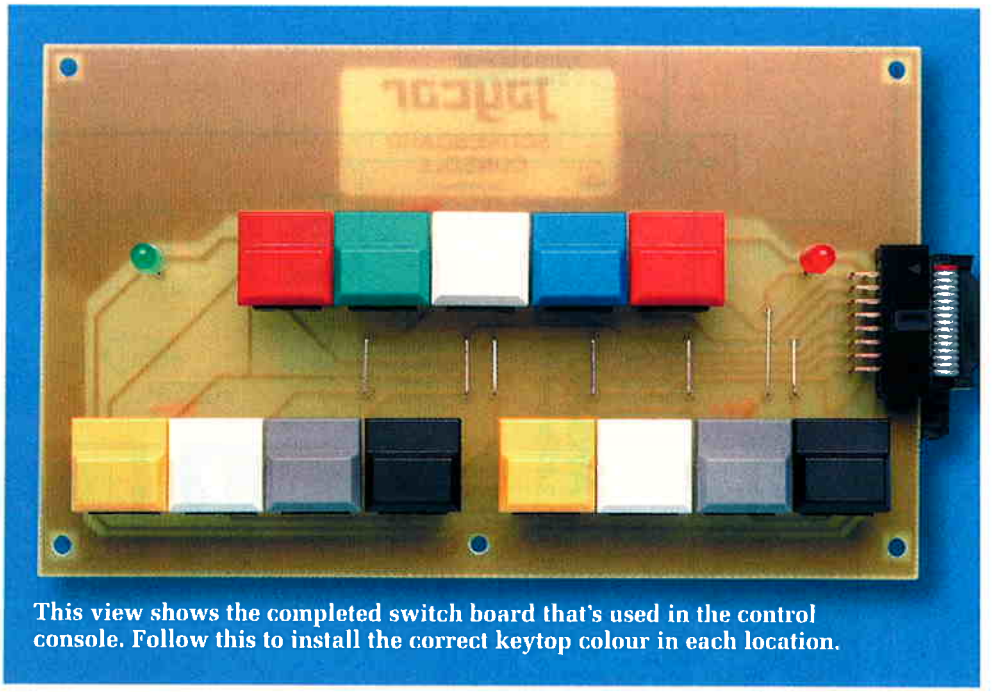
As shown in the photos, the Scoreboard's control console is built into a compact sloping-front ABS plastic case. This case measures 189 x 134 x 32/55mm and is listed in the Jaycar catalog as HB-6094.

Inside the case, most of the circuit components are mounted on a PC board measuring 178 x 111mm and coded BSBKYBD1. This fits snugly into the lower half of the case. The only remaining components are the keyswitches and the two indicator LEDs, which mount on a second smaller PC board measuring 163 x 100mm and coded BSBKYBD2. This switch board fits inside the top of the case, behind the front panel, and the two boards are connected together via a short length of 16-way ribbon cable fitted with IDC connectors.

The switch board is the easiest to assemble, so it can be built first. Fig.6 shows the parts layout diagram and

Pt.2: By JIM ROWE

oard



This view shows the completed switch board that's used in the control console. Follow this to install the correct keytop colour in each location.

as you can see, there is very little involved.

Start by fitting the seven wire links. These all run vertically down the centre of the board and can be made using tinned copper wire or resistor lead offcuts. That done, fit the 90° 16-way DIL connector (CON3) (the other vertically mounting header goes on the main console control board).

The 13 key switches can go in next. These all have four connection pins, plus two moulded plastic locating pins near diagonal corners, so they can only be fitted one way around. The main thing to watch is that you fit the correct colour keytop to each switch – just use the photo as a guide.

Note that the keytops are fitted by holding them at about 40° to the top of the switch body, so the two rear "hinge tabs" will slip down evenly into the recesses on each side of the rear of the switch. The keytops are then pushed down until the hinge pins click into place and the actuator rods also click in.

That done, check that the switches operate correctly. They should operate with a distinct click each time you press the keytops.

Once the switches are in, the only

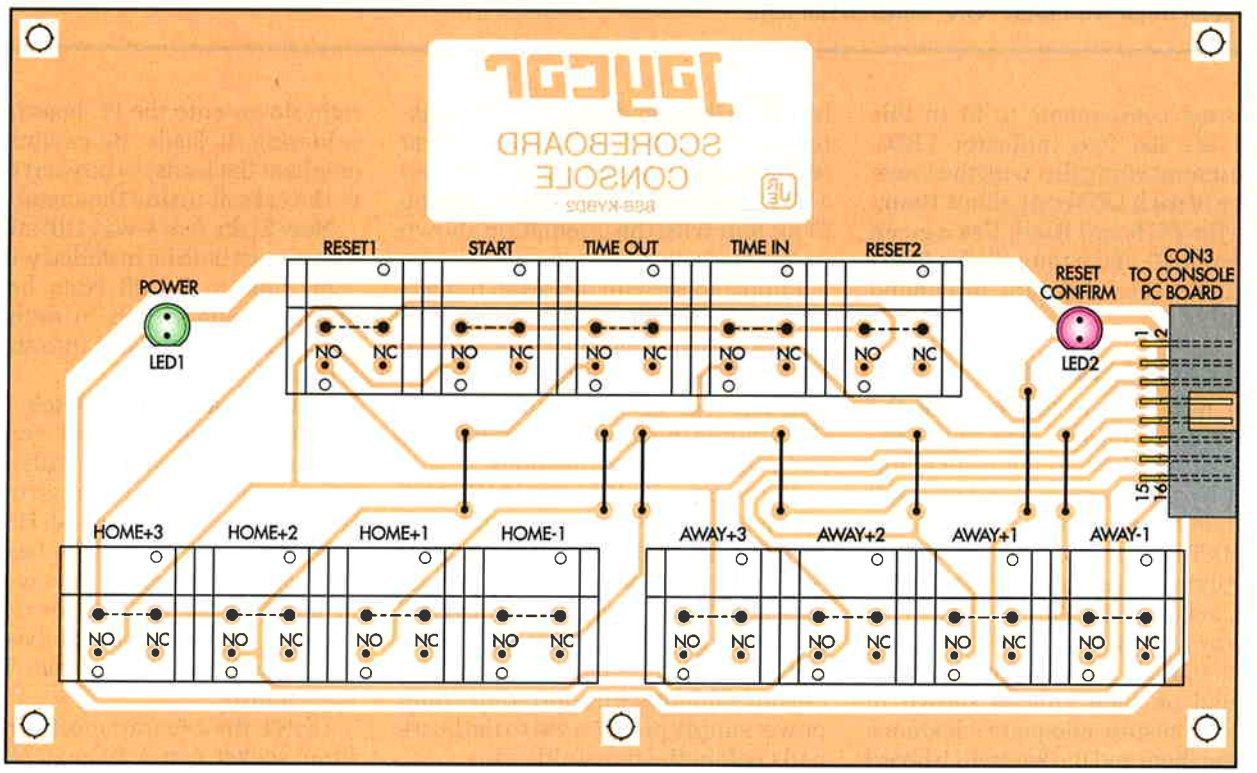


Fig.6: check that the switches are seated properly on the switch board before soldering their leads.

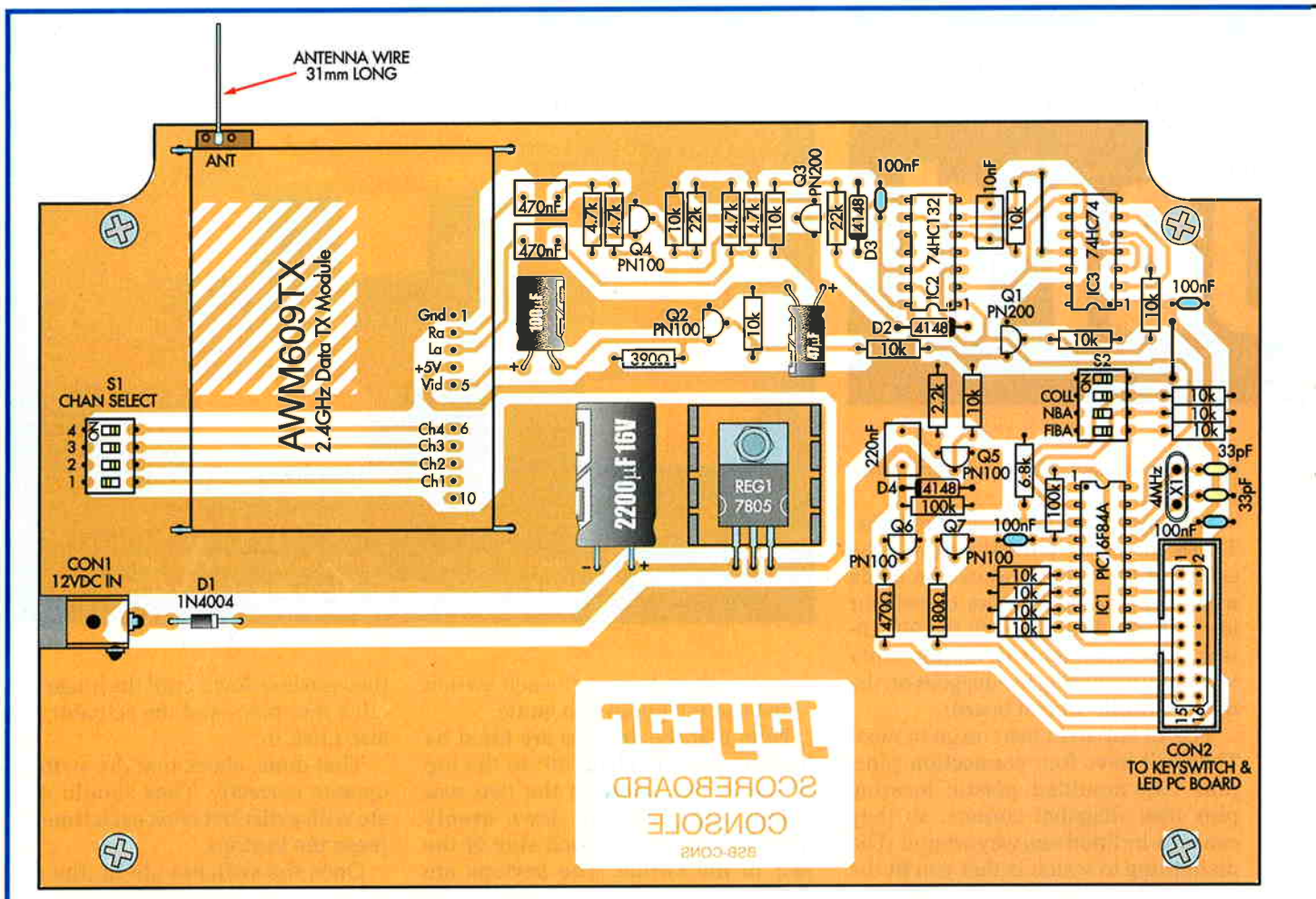


Fig.7: follow this diagram carefully when installing the parts on the main console board. Note that the two DIP switches must be fitted with their "ON" sides to the left.

remaining components to fit to this board are the two indicator LEDs. These mount vertically, with the lower surface of each LED body about 10mm above the PC board itself. Use a green LED for LED1 and a red LED for LED2 and make sure they are orientated correctly.

Main console board

The next step is to assemble the main console board – see Fig.7. Begin by fitting the two wire links, followed by the resistors and the small non-polarised ceramic, monolithic and MKT capacitors. The three larger electrolytic capacitors are fitted after these, making sure they go in the correct way around.

Note that all three electros must be mounted on their side as shown in Fig.7, to ensure adequate clearance between them and the keyswitch board when the console is later assembled.

Now for the semiconductors. Begin by fitting the four diodes (D1-D4), taking care to ensure that a 1N4004 power diode is used for D1 (D2-D4 are all 1N4148 signal diodes). Make sure you fit all four with the orientation shown in the diagram.

Follow these with the seven transistors and again check Fig.7 carefully to ensure each one has the correct orientation. Note also that the two PN200 transistors go in the Q1 and Q3 positions, while the five PN100 transistors go in the remaining positions.

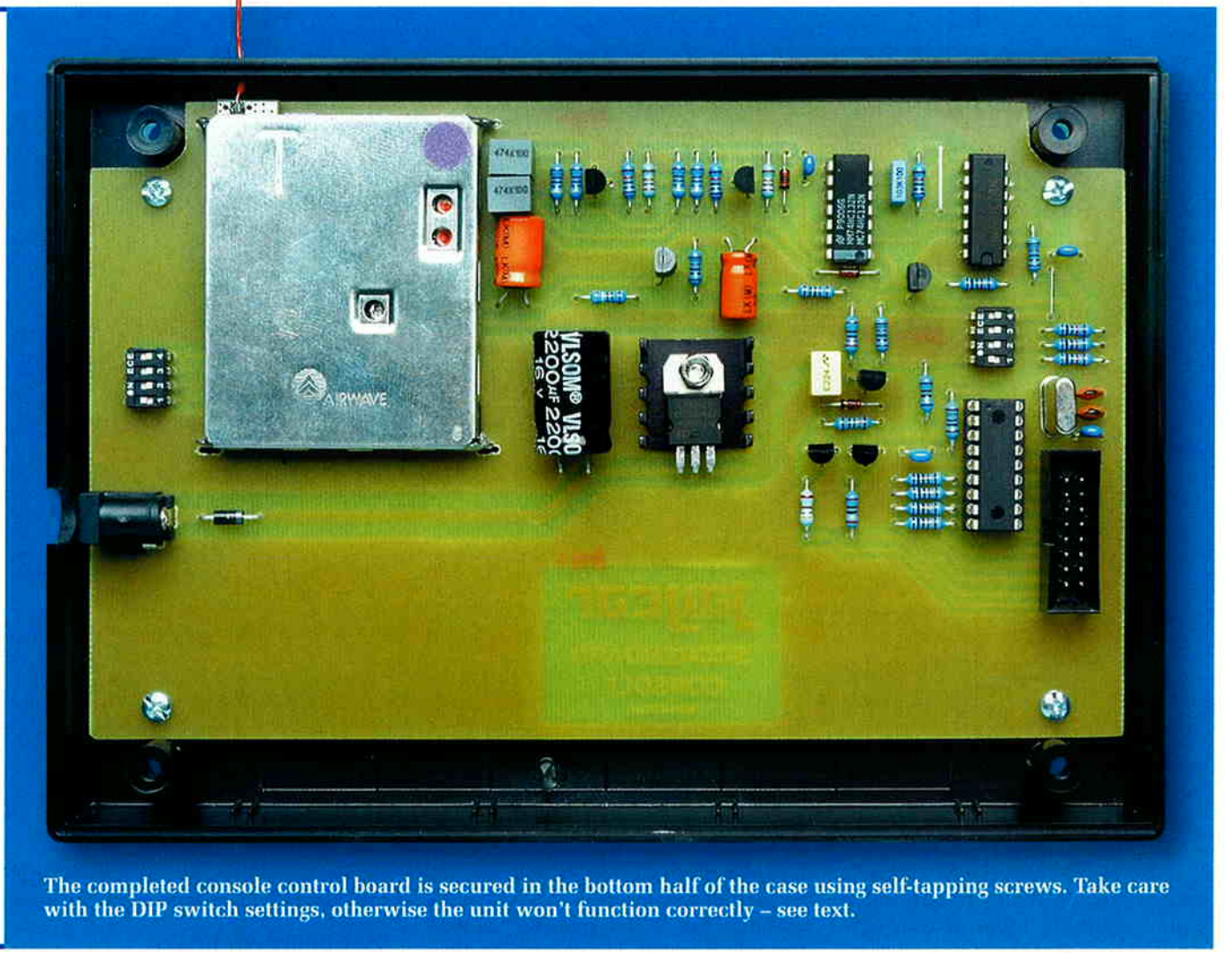
The two 14-pin ICs – IC2 (74HC132) and IC3 (74HC74) – can go in next. Install them with their notched ends orientated as shown on Fig.7. They are both CMOS devices, so take the usual precautions to prevent damage due to static electricity – ie, earth the barrel of your soldering iron and solder their power supply pins (7 & 14) to the board pads before the remaining pins.

The 4MHz crystal (to the right of IC1 is next on the list. It should be pushed right down onto the PC board, before soldering its leads. Be careful not to overheat the leads, to prevent damage to the crystal inside the metal case.

Now fit the two 4-way DIP switches. These must both be installed with their "On" sides to the left. Note, however, that only one switch in each group should actually be slid into the "On" position.

In the case of DIP switch S1 (the frequency channel select switches), we suggest that you initially set the "1" switch on, so that you can try using this frequency channel first. However, when it comes to S2 (the basketball code select switches), you will have to move either the 1, 2 or 3 switch to "On", according to the basketball code you'll be playing (see Table 1 last month).

CON1, the 2.5mm concentric power input socket, can go in next. Note that you may need to enlarge the mounting slots slightly with a jeweller's needle



The completed console control board is secured in the bottom half of the case using self-tapping screws. Take care with the DIP switch settings, otherwise the unit won't function correctly – see text.

file, so the socket lugs will slip through them. That done, fit the 16-way DIL header (CON2). It must be mounted with its centre-locating slot towards the left, as shown in Fig.7.

Next, fit the 18-pin DIL socket for the PIC microcontroller (IC1). This should be fitted so that the end recess is at the top, near DIP switch S2 (so that you will later install the IC the right way around).

Now for the +5V regulator REG1. This is fitted by first bending all three of its leads down by 90° 6mm from the regulator's body. That done, the regulator and its matching U-shaped heatsink (6073B type) can be attached to the PC board using an M3 x 6mm machine screw, nut and lock washer. Check carefully that everything is correctly aligned before soldering the three leads.

That done, the AWM609TX data transmitter module can be installed. Again, you may need to enlarge the mounting slots in the board slightly, so that the mounting lugs will all slip through. The lugs are then soldered to the copper underneath to secure the module to the board, after which its 10 connection pins can be soldered to their respective pads.

Once the transmitter module is in place, solder a 31mm length of 1mm brass wire to the centre pad at the top left. This serves as the module's transmitting antenna (31mm corresponds to a quarter of a wavelength at 2.4GHz).

The main console board can now be completed by plugging the programmed PIC16F84A microcontroller (IC1) into its socket. Be sure to install it with its notched end towards DIP switch S2.

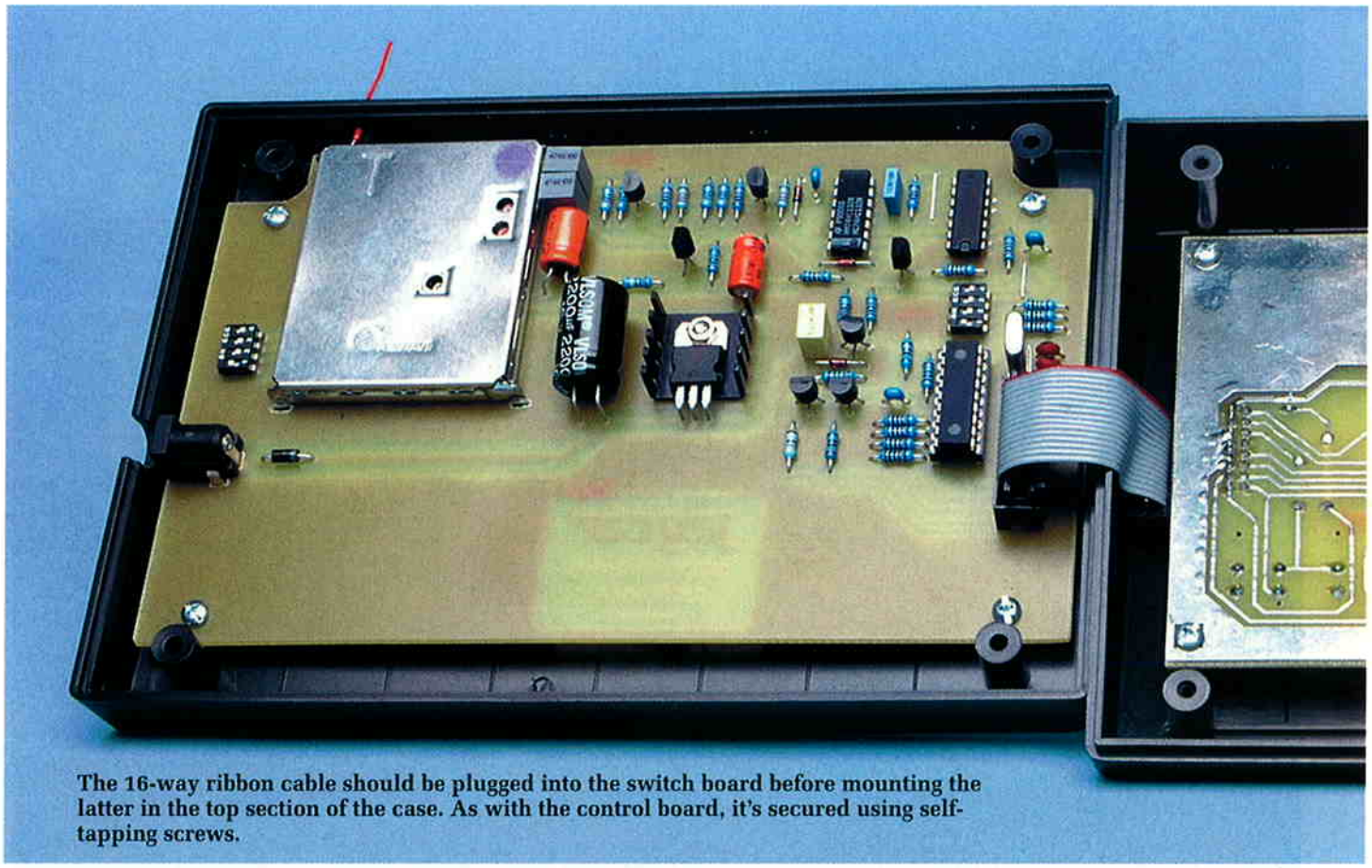
Console assembly

The completed console control board can now be mounted inside the bottom section of the console case. This is done by first slipping the antenna wire through a matching hole in the rear and then lowering the board until it's sitting neatly on the moulded plastic mounting pillars. Four 4G x 9mm self-tapping screws are then used to secure it in place.

A short length of 16-way ribbon ca-

Where To Buy A Kit

Jaycar Electronics has sponsored the development of this project and they own the design copyright. A full kit of parts will be available from Jaycar in due course – Cat. KC-5408. This kit includes a pre-built wooden display frame with screen-printed lettering and individual Perspex covers for the displays; screen-printed and solder-masked PC boards; all on-board parts; and a control console case with a pre-punched front panel and screened lettering.



The 16-way ribbon cable should be plugged into the switch board before mounting the latter in the top section of the case. As with the control board, it's secured using self-tapping screws.

ble is used to connect the two console boards together. This is only about 70mm long and is fitted with two 16-way IDC line sockets. These sockets must be fitted as shown in Fig.8, so that the cable can link the two board headers without problems when the case is assembled.

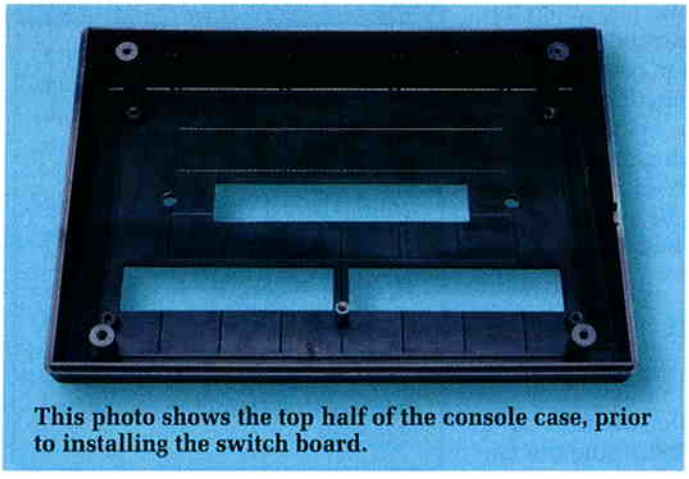
Once the cable has been made up, plug its end socket into the 16-way DIL header on the keyswitch board. That done, place this board inside the top section of the case, with its switch keytops passing through the matching rectangular holes in the front panel and the two LEDs passing through the round holes. The board can then be secured using five 9mm x 4g self-tapping screws.

Finally, plug the socket at the other end of the 16-way ribbon cable into its header on the main console board and dress the cable so that the two halves of the case can be swung together. The two case sections can then be fastened together using the four self-tapping screws supplied with it. That's it – the control console is now ready for use.

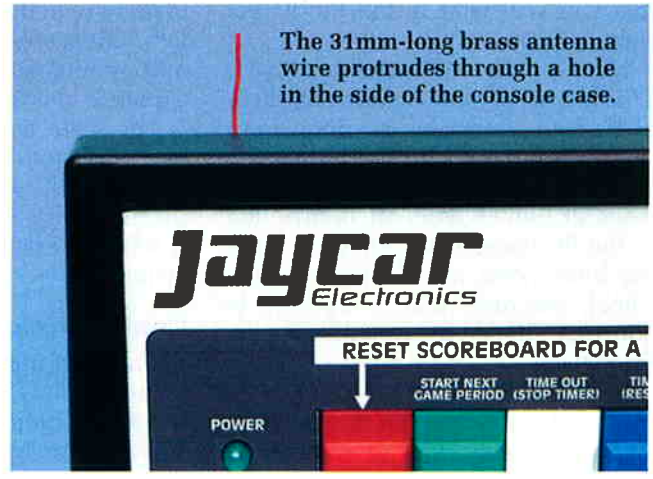
Main control board

Fig.9 shows the assembly details for the main control board used in the scoreboard.

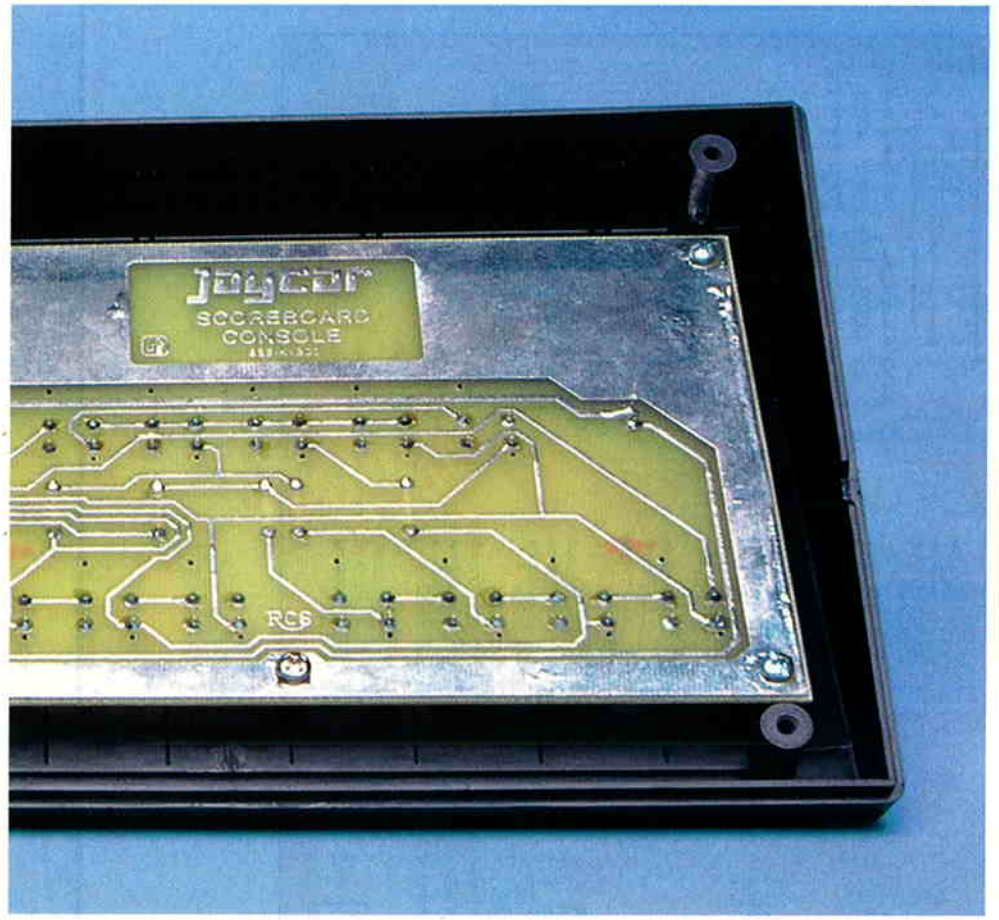
Begin by fitting the 14 wire links which can be made from resistor lead offcuts or tinned copper wire. The only exception is the first link immediately to the left of IC2 and IC3. This link should be run using insulated



This photo shows the top half of the console case, prior to installing the switch board.



The 31mm-long brass antenna wire protrudes through a hole in the side of the console case.



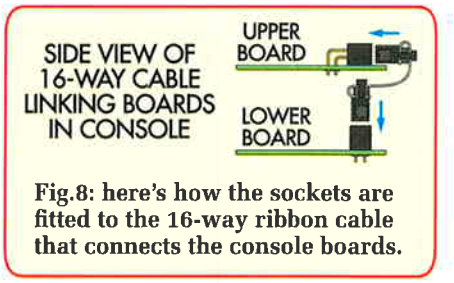


Fig.8: here's how the sockets are fitted to the 16-way ribbon cable that connects the console boards.

hookup wire, so there is no chance of it being able to contact either the adjacent IC pins or the equally long link on its left.

Once the links are in place, fit the single PC board terminal pin. This goes near the centre right of the board, to provide test point TP1. That done, you can install all the smaller components, including the resistors, diodes, crystal X1 (10MHz) and the capacitors. Be sure to fit the tantalum capacitors and the diodes with the correct orientation, as shown on Fig.9.

Similarly, take care with the orientations of the transistors. In particular, note that Q11 is a PN200 PNP transistor, while Q1, Q9, Q10 & Q12 are all PN100 NPN transistors.

Q2-Q8 are all MTP3055 power Mosfets. Each device is installed by first bending its leads down by 90° 7mm from its body and then fastening the device to the PC board using an M3 x 6mm screw and nut. Attach all the devices to the board in this manner, then solder the leads and trim the excess lead lengths.

Don't solder the leads before bolting the device tabs to the PC board. If you do, it could place strain on the solder joints when the mounting screw is installed, which could then crack the copper pads.

The 5V regulator (REG1) is installed is exactly the same way, except that it's fitted with a 6021 type U-shaped heatsink. Before assembly, apply a thin smear of heatsink compound to the underside of the regulator, to ensure that there's a good thermal bond between it and the heatsink.

The four CMOS ICs – IC2, IC3, IC4 & IC5 – can go in next. These are all CMOS devices, so be sure to observe the usual anti-static precautions (ie,

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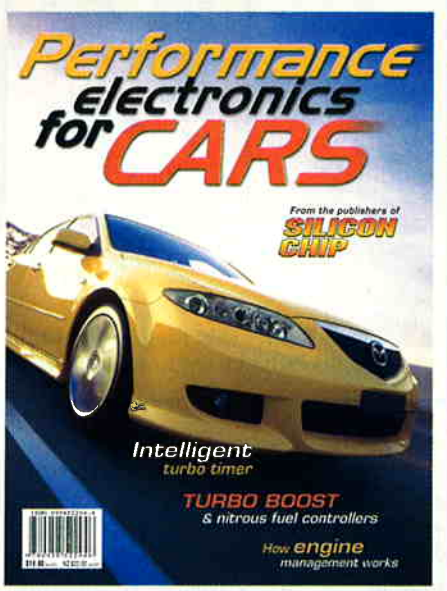
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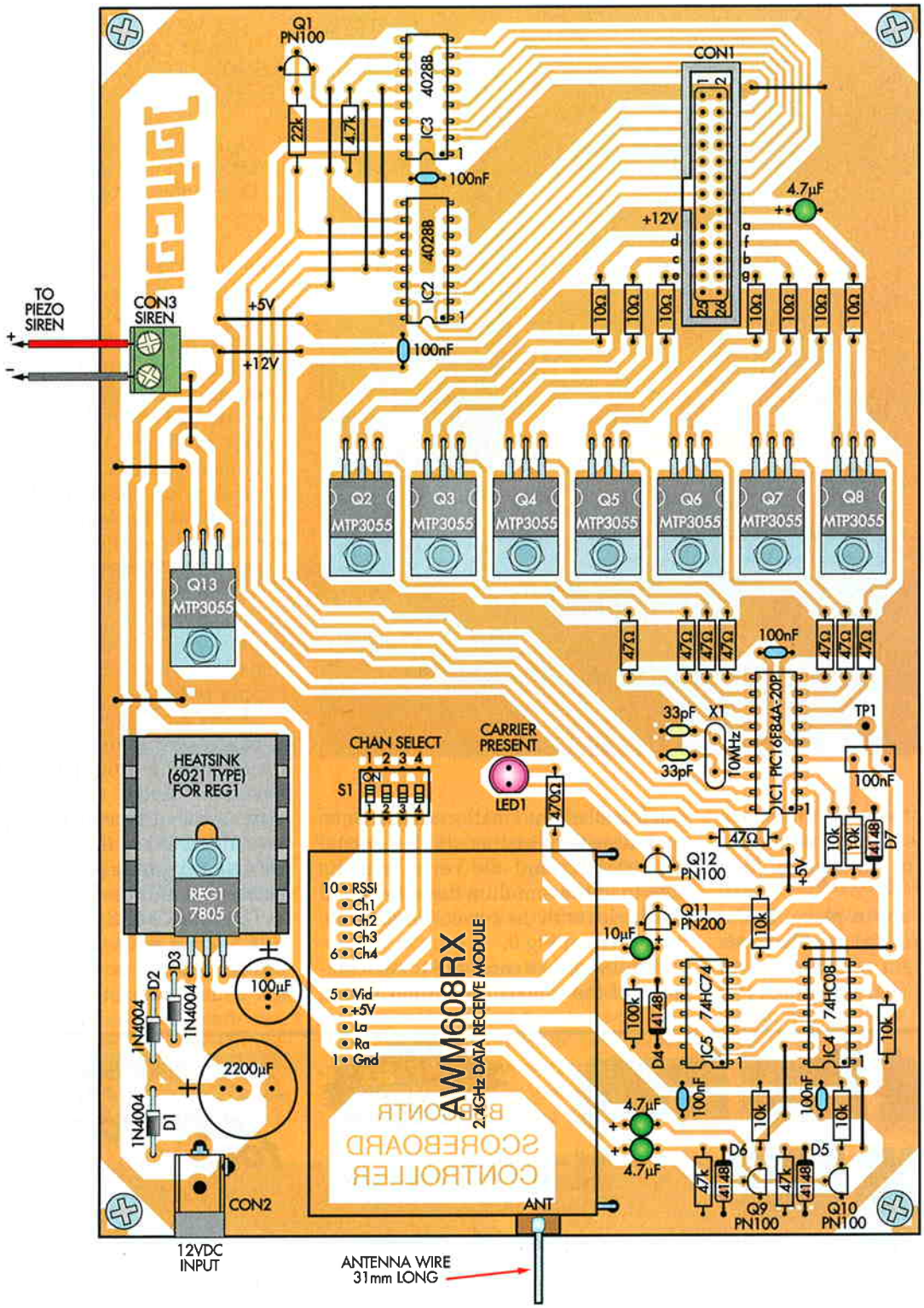
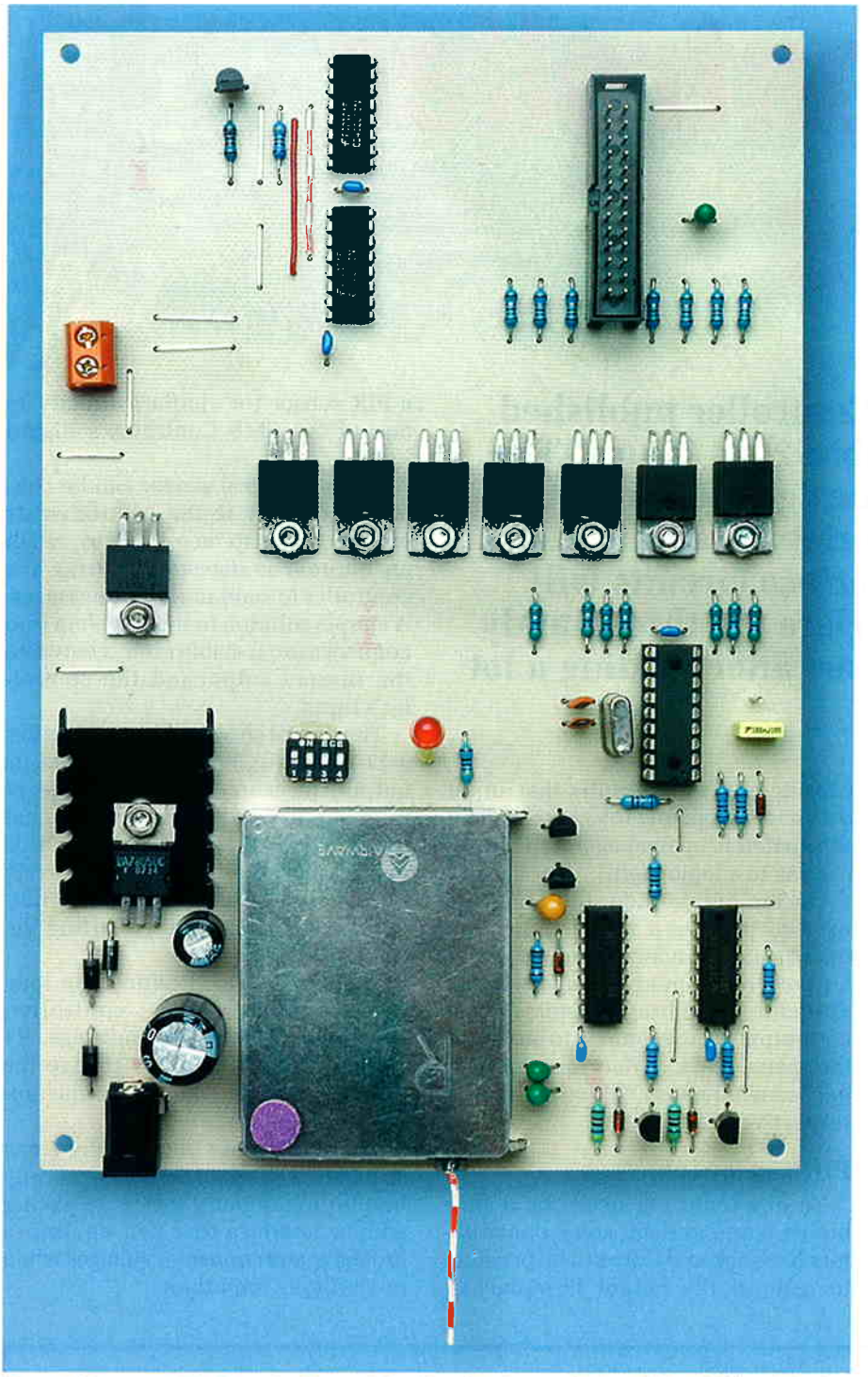


Fig.9: follow this diagram to build the main control board in the display unit. Note that DIP switch S1 (channel select) must be set to match DIP switch S1 in the control console.

earth the barrel of your soldering iron and solder their supply pins first (pins 7 & 14 for IC4 & IC5, pins 8 & 16 for IC2 & IC3). Make sure that these devices are all correctly orientated and that the correct device is used at each location.

As on the main console board, the PIC microcontroller (IC1) is installed in an 18-way DIP IC socket. Install this now, with its notch at the bottom end, to indicate the correct orientation when the microcontroller is later plugged in.

You can now fit the larger hardware



Your fully-assembled control board for the display unit should look like this. Observe all the usual precautions with component polarity.

items, starting with the 26-way DIL header (CON1), the 2.5mm concentric power connector (CON2) and the 2-way terminal block (CON3). Be sure to fit CON1 with its side locating slot towards the left, as shown on Fig.9.

Next, fit the AWM608RX data receiver module and the adjacent 4-way DIP switch (S1). Be sure to orientate the latter with the "On" side uppermost, as shown. Assuming you have set the console to channel 1, now is a good time to set this switch to the same setting – ie, set switch 1 in S1 to "On" and set the other three switches to "Off". This ensures that the transmitter and receiver both operate on the same frequency.

LED1, the power/carrier-present LED, is next on the list This goes near the centre of the board and is mounted vertically with its cathode (flat) side facing the receiver module. It's fitted with its leads left at full length, so that it's body will pass through a matching hole in the Scoreboard front panel when it's all finally assembled.

Before mounting the LED, fit both leads with 25mm lengths of 3mm varnished cambric sleeving (for insulation and support). That done, the leads can be passed through the board holes and soldered to the pads.

As in the control console, a 31mm length of 1mm brass wire is used as an antenna. This antenna is soldered to the centre pad of the AWM608RX data receiver's antenna terminals.

Finally, plug the PIC16F84A-20P microcontroller (programmed with SCORDISP) into its socket, making sure that the notched end faces towards the adjacent 47Ω resistor. And that's it – the display control board assembly is now complete and you can start building the four display boards.

That's all we have space for this month. Next month, we'll describe the display board assembles and give the wiring and check-out details. **SC**

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SMS Controller Add-ons

by PETER SMITH

Did you build the SMS Controller published in the October & November 2004 issues? The universal nature of the design means that it can be used in a huge variety of applications. As a result, external interface circuits will sometimes be required. Here are three handy add-ons that we've devised after reading a lot of your emails!

OUR THREE ADD-ON circuits for the SMS Controller are as follows: (1) a test jig; (2) a PIR sensor interface; and (3) a low-battery alarm. Let's start with the test jig.

Test jig

After suitable message programming, all of the controller's inputs and outputs can be tested with little more than a length of wire and a multimeter. However, if you want to do some serious bench testing or just want to demonstrate your completed project, a simple test jig with LED indicators can be constructed to make life easier.

As shown in Fig.1, push-button or toggle switches can be connected between each of the inputs and ground. Closing any switch pulls that input down to a logic low (0V) level. When the switch is opened again, the input returns to a logic high.

On the output side, the LEDs are used to provide a visual indication of the state of each channel. All LEDs are powered from +12V via individual 1kΩ current-limiting resistors. When any output is programmed to be "low", the open-collector driver for that channel is switched on, illuminating the respective LED.

PIR sensor interface

To eliminate the need for a full-blown alarm system, some constructors have asked if it would be possible to connect the output terminals of a PIR sensor (or similar) directly to one of the SMS Controller's digital inputs.

While a typical sensor can be connected directly to the controller, its output will trip many times when an intruder is detected, causing the controller to send multiple messages. A simple solution to this problem is to connect a monostable circuit between the sensor's output and the controller's input.

The circuit shown in Fig.2 provides a 114s (approx.) positive pulse at its output, measured from the time of the last pulse at the input. Additional input pulses that occur within this period retrigger the monostable via transistor Q1, discharging the timing capacitor (C1) and restarting the timer.

The effect is to produce one long positive pulse for the controller, meaning just one alarm message. R1 and C1 can be altered to change the pulse width for your particular application.

The additional circuit in Fig.3 can be inserted ahead of the power supply inputs of the monostable (or any other add-on interface that you devise) to protect against transient voltages when reliability is important.

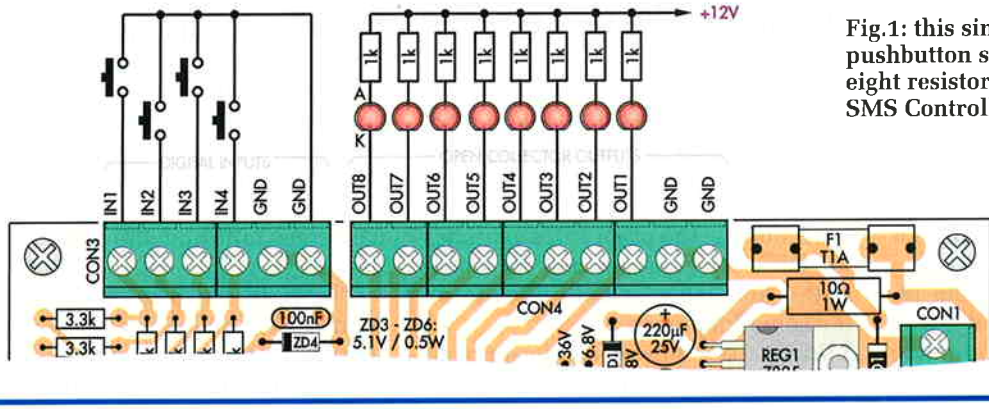


Fig.1: this simple test jig uses four pushbutton switches, eight LEDs and eight resistors to demonstrate that the SMS Controller is working correctly.

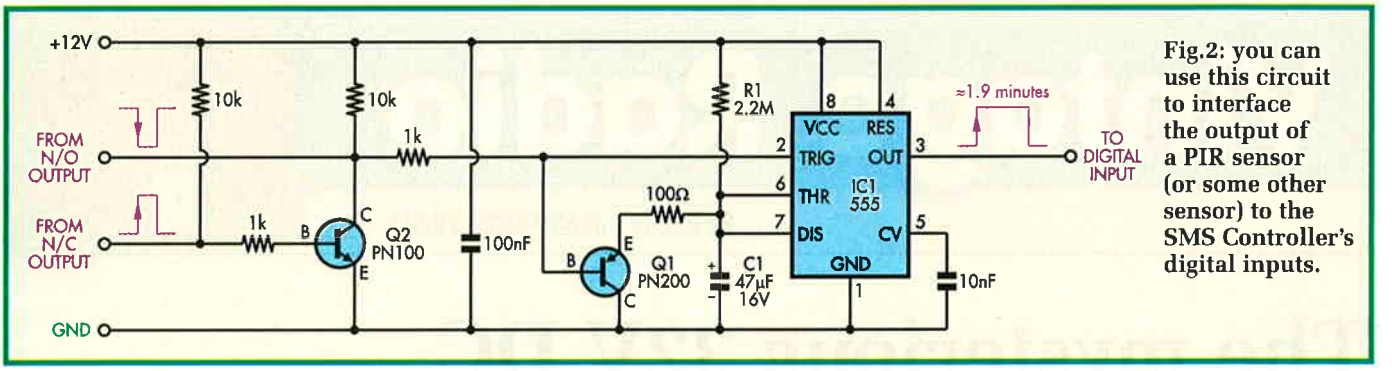


Fig.2: you can use this circuit to interface the output of a PIR sensor (or some other sensor) to the SMS Controller's digital inputs.

Note that the jumper for the associated 3.3kΩ pull-up resistor on the controller input should be removed, as it is not required when driven from the 555's totem-pole output.

Low-battery alarm

Several constructors have requested a low-battery alarm add-on for the SMS Controller. Although a number of circuits would be suitable for this job, perhaps the easiest approach is to modify the Micropower Battery Protector, published in the July 2004 edition of SILICON CHIP.

The original project is designed to disconnect a battery from its load when the terminal voltage drops below a preset value. In this case, we require only the voltage monitoring circuit and can dispense with the Mosfet switch (Q1) and a few other components (see Fig.4).

The circuit is based around the MAX8212 Voltage Monitor (IC1), which compares a scaled-down version of the input voltage (set by R1, R2 & VR1) on the THRESH pin with an internal 1.15V reference. When the input (battery) voltage is above the preset value, the open-drain output on pin 4 is grounded. Conversely, when the input voltage falls below the preset value, the output goes open circuit.

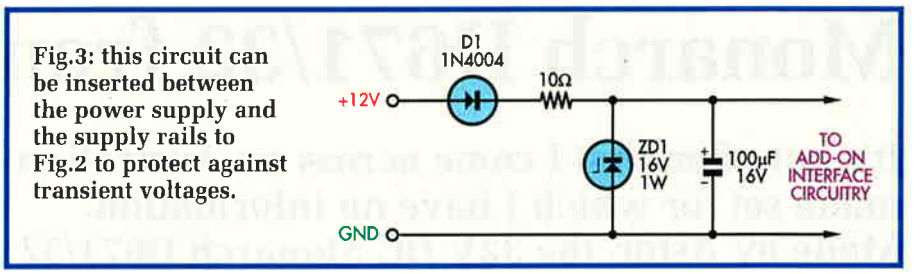


Fig.3: this circuit can be inserted between the power supply and the supply rails to Fig.2 to protect against transient voltages.

Although the circuit could be constructed on a prototyping board, the easiest route would be to partly assemble the original Micropower Battery Protector PC board. A matching overlay diagram appears in Fig.5, showing how to populate the PC board for the low-battery alarm function.

The fuse (F1), Mosfet (Q1), 220nF capacitors and zener diode (ZD3) that were part of the original design are all omitted. Two links are added in place of the fuse and Mosfet and a 100Ω resistor is substituted for the 1MΩ value to the left of the existing 100Ω resistor.

The battery to be monitored connects to the input terminals and the "+" output connects to one of the inputs of the SMS Controller. The jumper for the associated 3.3kΩ pull-up resistor on the controller input should remain in place, as the low-battery alarm's output is open-drain.

Where to get stuff

Copies of the July 2004 issue are available from our subscription department. A kit of parts for the Micropower Battery Protector is available from Dick Smith Electronics (Cat. No. K3132). Alternatively, blank PC boards can be obtained from RCS Radio (board no. 11107041) while MAX8212 ICs are available from Wiltronics, on the web at **www.wiltronics.com.au** SC

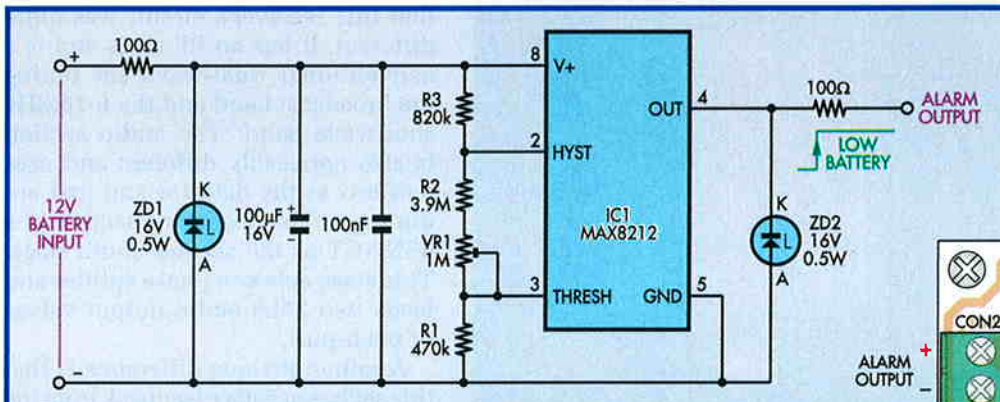
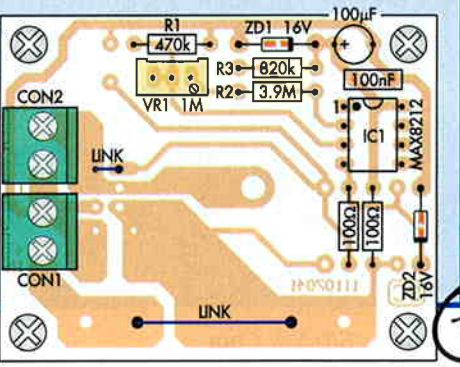


Fig.4: a low-battery alarm add-on is a handy feature. This circuit is based on the Micropower Battery Protector (SILICON CHIP, July 2004). When the battery voltage falls below a preset value, pin 4 of IC1 goes open circuit.

Fig.5 (below): the original PC board for the Micropower Battery Protector can be used to build the low-battery alarm. This diagram shows the revised parts layout.



Vintage Radio

By RODNEY CHAMPNESS, VK3UG

The mysterious 32V DC Monarch D671/32 from Astor

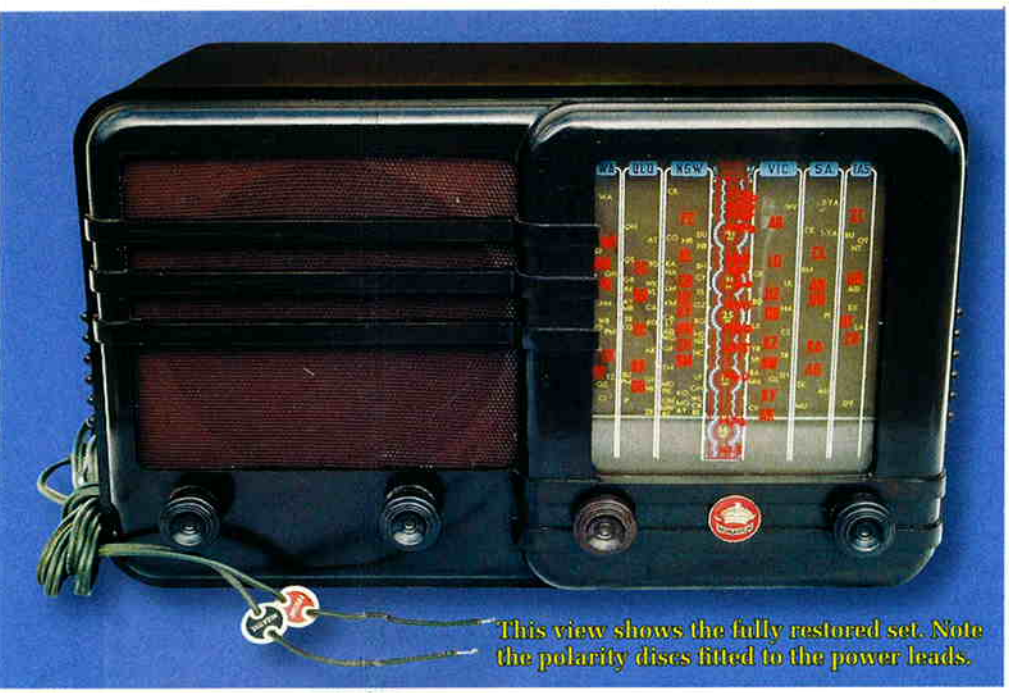
It's not often that I come across an Australian-made set for which I have no information. Made by Astor, the 32V DC Monarch D671/32 falls into that category and may have been a pre-production model.

Every so often, I come across a radio for which I am unable to find any information. Perhaps it's an orphan from a particular radio manufacturer's family or for some reason, the manufacturer omitted it from the list of receivers published in the Australian Official Radio Service Manuals (AORSM) or other trade publications.

These omissions make it just that much harder to service the "unknown" set – particularly if it has been modified (or "improved") since manufacture. How often have you obtained a set that has been modified and have had to resort to the published information to restore the receiver to its original specifications?

The Monarch brand is one of several Astor clones – like Peter Pan, National and Airchief, etc. However, I looked through all the Monarch information for this particular set without success. Because it is a 32V DC operated set, I then searched for any Monarch that had a similar valve line-up that used 32V high tension (HT), still without success.

My next step was to check all Astor clones in my various books and service manuals but that didn't turn up anything either. I had hoped that I would at least find a receiver with a nearly identical circuit but I had no luck at all.



This view shows the fully restored set. Note the polarity discs fitted to the power leads.

Astor circuits

Astor sets and Astor clones that use 32V for the heaters and HT supply (late 1940s and early 1950s) usually have a multi-band radio frequency (RF) stage, a converter and two IF stages. This is then followed by a detector and first audio stage, a 25L6 audio driver feeding a push-pull inter-stage audio transformer, and a pair of 25L6 valves in push-pull feeding the loudspeaker. The RF section tunes the broadcast band and three bandspread shortwave bands.

However, it was obvious to me that this receiver's circuit was quite different. It has no RF stage and is a conventional dual-wave set tuning the broadcast band and the 6-18MHz shortwave band. The audio section is also noticeably different and uses a 6G8-G as the detector and first audio stage. This feeds one section of a 6SN7-GT as the second audio stage. This stage acts as a phase splitter and feeds two 25L6 audio output valves in push-pull.

Another obvious difference is that this set has negative feedback from the speaker voice coil winding to the grid of the first section of the 6SN7-GT. By contrast, the common Astor 32V (HT) sets don't use negative feedback.

It really is rather puzzling as to why this circuit differs so much from the one almost universally used by Astor for 32V radios. Perhaps this was an experimental, limited production run, economy model receiver? Its circuit is certainly simpler than Astor's other 32V receivers. However, it's still quite a complex receiver when compared to sets like the Diason described back in the February 2002 issue.

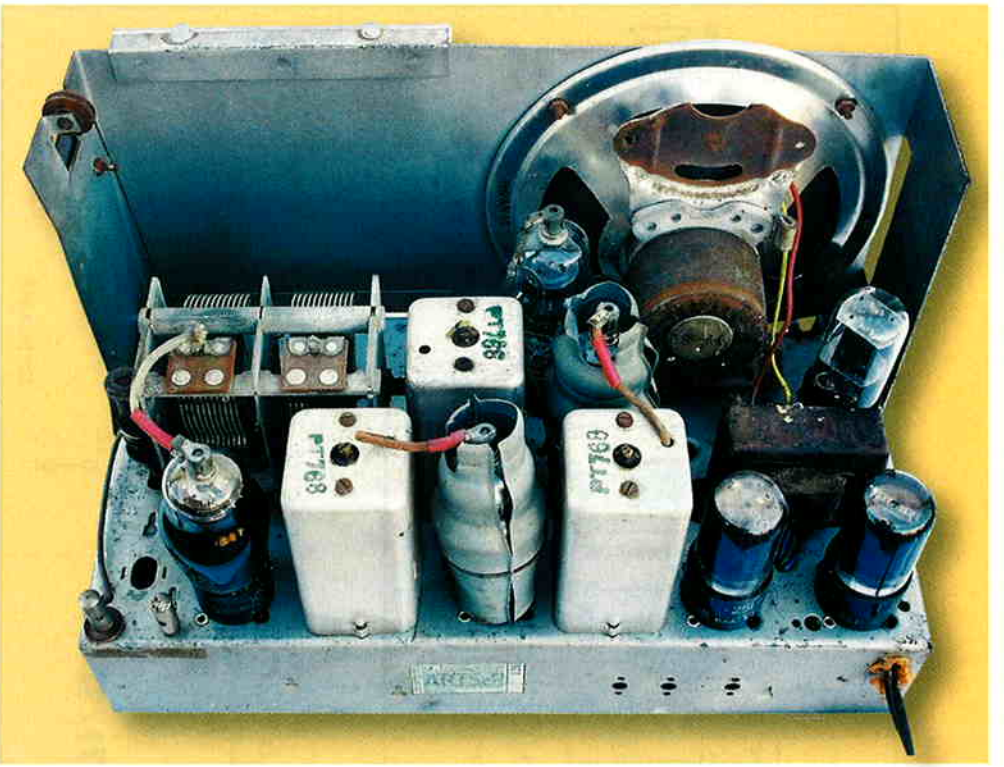
Tracing out the circuit

Before tracing out the circuit, I did what I normally do – I dusted the chassis and then cleaned it using kerosene on a kitchen scouring pad. This not only makes the set a lot more pleasant to work on but also makes the job easier. It's got to be done sooner or later, so why not when the chassis is first removed from the cabinet?

Unfortunately, it's not a particularly easy circuit to trace, as most of the wiring has been run in a single colour – in this case, rubber-coated wire that's a faded yellow colour. However, armed with a valve data book and circuits of similar 32V radios, I set to and traced out the circuit.

Lots of components had been replaced in this set during its life, so a complete circuit would quickly reveal if any "strange" circuit alterations had been done. As it turned out, it proved to be almost original, the main exception being that the previous owner had rewound the shortwave coils (and altered the padder to suit the new band), so that it tuned from 2.6-7.5MHz. He had even painted the new dial calibrations on the dial scale!

There was a reason for this – the original owner (now deceased) had been a radio amateur and had wanted to tune the 3.5MHZ and 7.0MHz amateur bands plus the two bushfire brigade frequencies he was licensed to use (2692kHz and 2836kHz).

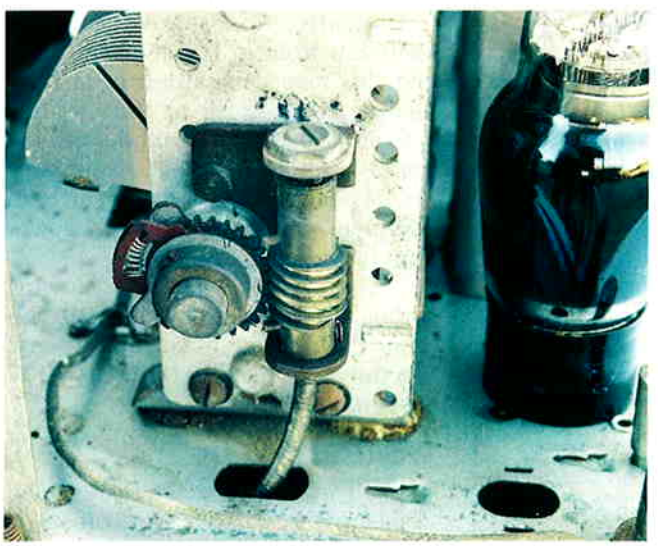


The chassis layout of the Monarch D671/32 is quite conventional (photo taken before restoration). It's a 32V set that covers both the broadcast and shortwave bands and uses seven valves.

Circuit overview

Fig.1 shows the circuit details of the Monarch D671/32. It's really quite conventional for a receiver using a 32V HT rail. However, it did surprise me that the screens of all the RF valves were fed through resistors, to reduce the screen voltages below the already low 32V on the plates. The similar Astor clones also did this but they also had an extra valve in the RF chain which meant that more care was necessary to ensure stable operation.

As shown on Fig.1, automatic gain control (AGC) is applied only to the converter and first IF stage. AGC is not applied to the second IF valve as a strong signal would push the valve into a non-linear amplifying condition near cut-off and cause distortion. This occurs because with such a low HT voltage, the valve has a very narrow



The old Monarch D671/32 was fitted with a gear driven tuning capacitor, as shown in the photo at left. The close-up above shows an overheated 0.47µF paper capacitor that's located too close to a high-wattage resistor.

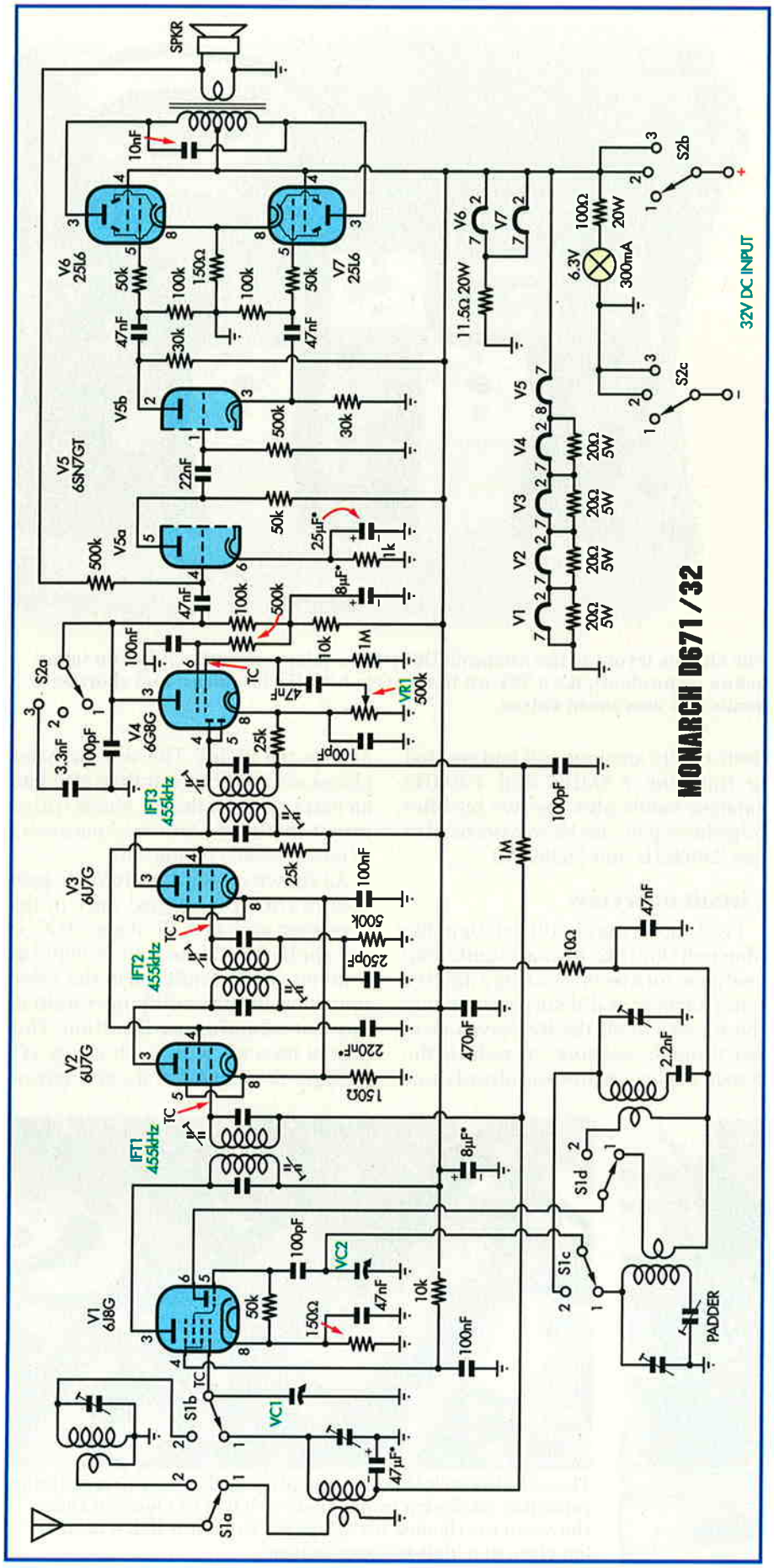


Fig.1 (left): the complete circuit for the Monarch D671/32 receiver. Note that the audio output stage employs two 25L6 valves operating in push-pull configuration.

operating range over which it amplifies linearly. If the valve had a normal HT voltage of around 200V applied to it, this would not be a critical concern.

The audio amplifier is similar in design to many medium-power public address amplifiers of the era. What makes it different is that it uses a HT voltage of just 32V.

So why use two 25L6 valves in a push-pull configuration? With only 32V HT, the valves draw very little current, so two are necessary to get reasonable output from the speaker. Because they are in push-pull, the valves can be driven a bit harder than otherwise, to give more output before distortion becomes objectionable.

In this case, the audio output is about 300mW, hence the use of a 6-inch (150mm) loudspeaker to ensure a reasonable audio level.

Normally, 25L6 valves are designed to work effectively with a HT voltage of about 110V, whereas valves like a 6V6G are designed for HT voltages of 200-250V. This means that a 6V6G would not work well in this set, as it would draw very little plate current.

Power supply

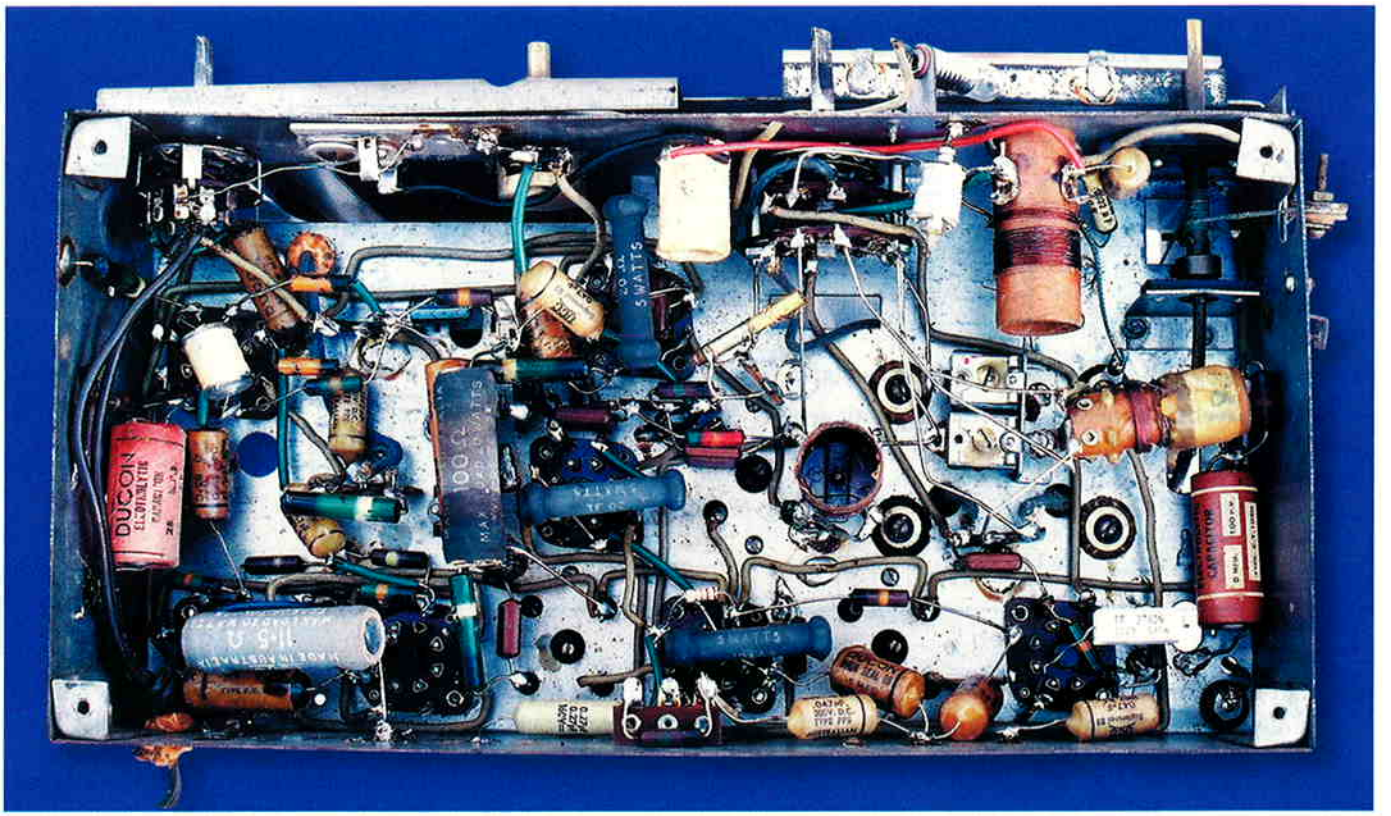
The 32V power supply is connected to the receiver via a 2-core lead and each lead is identified by a small brass label which indicates whether it is positive or negative. This is a useful feature that I haven't seen on other DC-powered radios.

Typically, this set would have been run from a 32V lighting plant and this may have either been fully floating above earth or the negative side may have been earthed. Both the positive and negative power leads are switched, so that the receiver is completely isolated from the power supply when it's turned off.

This prevents current from flowing through the set's earth to the batteries when the set is off, which could cause electrolysis effects in the whole 32V system.

Wasteful circuits

The way in which the heaters and dial lamps are wired to work off 32V is



There are lots of components under the chassis but this is still an easy set to service. There are lots of factors which indicate that this was probably an experimental model which never went into full production – see text.

quite wasteful, both in parts and power consumption. First, the 6SN7GT valve draws 0.6A of heater current but its heater is wired in series with the other 6V valve heaters which draw just 0.3A. As a result, 20Ω 5W equalising resistors are wired in parallel with these latter valve heaters, to draw the extra 0.3A required – ie, to bring the total current drain up to 0.6A.

Similarly, the heater wiring to the two 25L6 valves is hardly efficient. These valves each draw 0.3A of heater current and are wired in parallel. They are also wired in series with an 11.5Ω resistor which drops the voltage across the heaters from 32V to around 25V.

In practice, it would have made more sense to wire the 6SN7GT's heater in place of the 11.5Ω resistor, remove all the 20Ω resistors across the heaters, and install a 20Ω resistor in place of the existing 6SN7GT heater.

The dial light is a 6V 300mA unit which is fed from the 32V rail via a 100Ω 20W resistor. However, by using a 12V 150mA dial lamp (available when this set was built) and changing the series resistor to 170Ω, the current would have been halved. In addition, the amount of under-chassis heating would have been substantially reduced. The result of this heating can be seen in one of the photographs, which shows a 0.47µF capacitor with the 100Ω 20W resistor immediately above it.

Using the original heater and dial-lamp supply circuitry, the total current is 0.6A (25L6 line) + 0.6A (6SN7GT line) + 0.3A (dial lamp) = 1.5A. With my suggested heater and dial-lamp modifications, this current would be reduced to 1.05A, which is a considerable saving.

On a 32V system, a kilowatt-hour of energy would have cost at least $2 (as opposed to around 15c today), so saving power was important. The HT current in this receiver does not exceed 50mA, so this is inconsequential when calculating the receiver's total current drain.

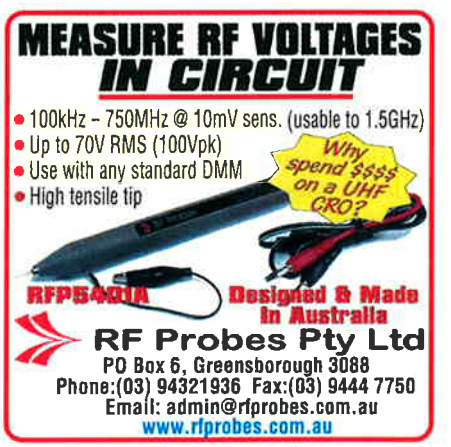
One curiosity is that the power switch has three positions: (1) "off", (2) "on" and (3) "on with top cut of audio frequencies". I believe that it would have been better if this had been changed to: (1) "off", (2) "charge" and (3) "on".

To explain, when the batteries in a 32V home lighting plant were being charged, the voltage could reach as high as 40V if the normal 16-cell bank of batteries was used. And if an extra cell or two had been added to the bank to overcome voltage drops in the cables, the battery voltage could rise to as much as 45V during charging.

Clearly, this is not good for the valve heaters. As a result, some 32V receivers have a "charge" position to reduce the voltage to the valve heaters to somewhere near their rated voltage. This is achieved by installing a wirewound resistor in series with the supply line.

The smoke test

Armed with my hand-drawn circuit diagram, a 32V DC power supply and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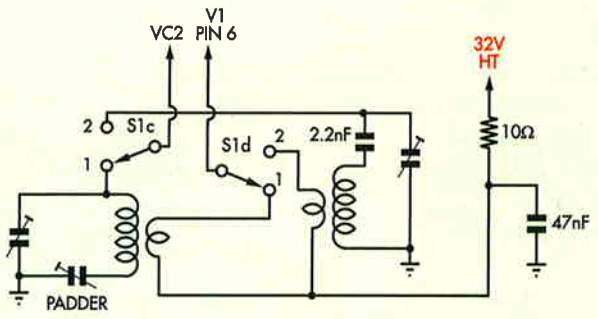
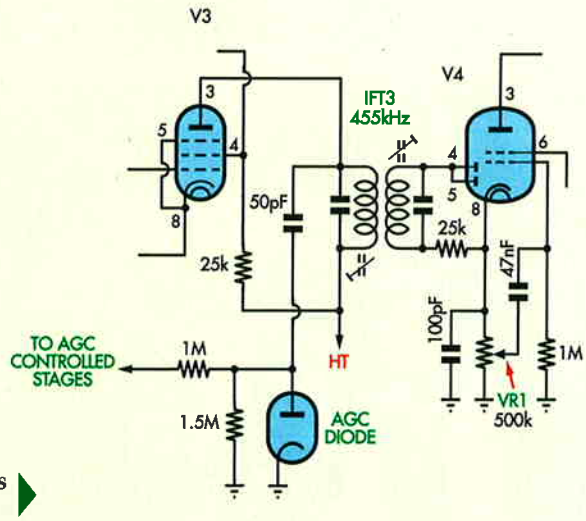


AMENDED SHORTWAVE OSCILLATOR CIRCUIT

Fig.2 (above): this amended oscillator circuit gives much improved performance on shortwave.



AMENDED AGC CIRCUIT

Fig.3 (right): the amended AGC circuit. The added AGC diode is fed from the plate of the second IF amplifier (V3) and this gives higher AGC voltages than before.

my trusty digital multimeter, I decided to give the set a thorough check out. Normally, in a mains-powered receiver, I would check the capacitors before applying power. However, because the voltages are so low in these 32V sets, there's not much risk of damaging valves or other components due to faulty parts – at least, not in the short term.

The dial lamp had obviously blown so a new one was installed, after which the set was connected to a 32V power supply and switched on. The dial lamp glowed nicely but there was no sign of life in any other sections of the receiver – in fact, the valve heaters didn't appear to be lighting at all.

As a result, I checked the valve heaters for continuity and found that they all had open circuit heaters, the only exception being the 6J8G which had at some time been replaced with a 6J8GA. So what had caused this catastrophic failure in the valves? To me, it indicated that someone had probably tested the set by connecting it to 240V AC and found that it produced nothing but smoke! And in the process, six out of the seven valves were ruined.

If the set had been fitted with a fuse, little damage would have occurred, although it could have proved fatal had someone touched the chassis. In a 32V environment, the chassis is earthed and 32V is not usually considered lethal, although it can give you a nasty little surprise if you are perspiring profusely.

But why was the 6J8GA's heater still intact? The original valve used was a 6J8G which has a 0.3A heater, while the substituted 6J8GA has a 0.45A heater. This meant that it was better able to cope when the 240V was applied and the other heaters went open circuit before this one got to the point of burning out.

This has also meant that I had to replace its 20Ω heater equalising resistor with a 47Ω resistor, so that around 6V is applied to the 6J8GA's heater.

With so many valves ruined, it proved to be a relatively expensive exercise to replace them. This time, when the power was reconnected, there was a dreadful hum from the loudspeaker. The volume control had no effect on this hum and, in addition, no stations could be heard.

It didn't take long to track down the problem – the 8µF capacitor in the decoupled HT supply to the 6G8G was faulty, with very low capacitance. I replaced it a 33µF 63V unit that I had on hand and that got rid of most of the hum. However, the set's performance was very poor, the unit exhibiting poor sensitivity and a distorted audio output.

I checked the voltages on various stages and soon found that the screen pins of the two 6U7G valves were at only 5V. This was due to two factors: (1) a leaky 270nF screen bypass capacitor; and (2) the 25kΩ screen dropping resistor intermittently going open circuit. They were both replaced and the performance was vastly improved.

The receiver was now starting to show some promise. I checked the tuning range on the broadcast band and adjusted the oscillator padder at the low-frequency end of the dial and the wire trimmer at the high-frequency end, so that stations appeared in the correct places. I then adjusted the trimmer on the antenna coil towards the high-frequency end of the band for peak performance.

Next in line was the IF amplifier stage and after making the necessary adjustments, the set really started to perform. These IF adjustments were carried out with the aid of a signal generator and an insulated alignment tool.

Unwanted whistle

Although it was now performing quite well, there was still an occasional "whistle" from the set. A few checks soon revealed that the IF amplifier stage was oscillating. The reason for this was straightforward – the close-fitting metal shield (also known as a "goat" shield) on one 6U7G was loose, so I compressed the circlip that held it together. The shield now worked properly and no further whistles occurred. However, I did notice that the set oscillated weakly at the low-frequency end of the broadcast band (more on this later).

I next checked the shortwave band and found that it tuned as the altered dial-scale indicated – ie, from 2.6-7.5MHz. In practice, it worked quite well down to 3.3MHz but below that, it ceased to operate. I suspect

that the oscillator stops at about this frequency, which effectively kills the set's operation.

Some readers will be aware that I dislike having padder capacitors in the earthy end of the oscillator's tuned winding. That's because oscillators often have reliability problems when the padder is in this position.

As a result, I decided to do as I've often done before and change the position of the padder on the short-wave band. This involves moving it to the other end of the oscillator coil. The amended circuit configuration is shown in Fig.2.

When I did this, the shortwave operation improved noticeably and, what's more, it now worked right across the band. That done, the receiver was aligned using a combination of the techniques described in the December 2002 and the January and February 2003 issues.

Faulty capacitors

Paper capacitors in particular have a reputation for becoming quite leaky. However, as explained in the articles in the October and November 2004 issues, not all leaky capacitors have to be replaced.

Rather than describe every component that was replaced, I've marked them with an asterisk (*) on the circuit diagram (Fig.1). They either had too much leakage or in the case of the electrolytics, low capacitance. Several other paper capacitors were also leaky but their circuit locations meant that they didn't cause any problems, so they were left in circuit.

By contrast, all those capacitors marked with an asterisk were replaced and each gave further improvements in performance.

Subtle problems

There is only one strong broadcast station where I live and I soon found that it overloaded the receiver quite noticeably. The strength of the signal is such that it drives the second IF amplifier into non-linearity. This is largely overcome by not applying AGC to the second IF amplifier – only to the two preceding stages.

In practice, I have found that higher AGC voltages need to be applied to the controlled stages than can be achieved with the simple AGC system fitted to this set. However, higher AGC voltages can be derived by having a separate AGC diode which is fed from the plate of the second IF amplifier.

Six out of the seven valves in the Monarch were faulty, probably because someone plugged it into 240V AC.

As an experiment, I altered the set's AGC circuit to this system (see Fig.3) and the improvement was dramatic, with little remaining evidence of overloading. I suspect that Astor clones with an RF stage had better AGC control by having AGC applied to three stages instead of just two, as in this receiver.

As mentioned earlier, the receiver oscillates weakly at the low-frequency end of the broadcast band. I checked the earthing of the valve shields and the IF transformer cans, looked at the bypassing around the RF/IF sections and even tried adding extra IF (455kHz) filters in the audio amplifier stage, all to no avail. However, any radio station worth listening to overcomes this problem. That's because the AGC reduces the gain and hence the amount of feedback drops below the level that causes the oscillation.

My conclusion is that it's the receiver's wiring layout that causes this problem. In this set, the detector is relatively close to the front-end circuitry. As a result, radiation of 455kHz IF energy from the detector is amplified sufficiently in the aerial circuit to cause oscillation when it's tuned towards the low-frequency end of the band.

It's worth noting that aerial coils don't have a particularly high "Q", so they will respond slightly to signals around 455kHz when a set is tuned to low frequencies.

Wiring & dial cord

Most of the wiring has been left in-situ, as it's not causing any problems

Many of the paper and electrolytic capacitors had to be replaced, along with some of the wiring which had cracked insulation.

Photo Gallery: Astor Mickey Mouse Model EC

Manufactured by Radio Corporation, Melbourne, in 1939, the "Mickey Mouse" EC was a 5-valve superheterodyne receiver fitted with metal valves. Using an output valve that gave good performance at relatively low operating voltages allowed the size of the power transformer to be reduced and also reduced the heat build-up in the small Bakelite cabinet (the white cabinet shown here was not common). The valves fitted were as follows: 6A8 frequency changer; 6K7 IF amplifier; 6Q7 audio amplifier/detector/AGC rectifier; 25A6 audio output; and 5Z4 rectifier. Photo: Historical Radio Society of Australia, Inc.

and is unlikely to do so if left undisturbed. However, the insulation on some of the wiring had cracked and that meant it had to be replaced (see photo).

But I wasn't quite out of the woods yet – just as I was about to finish all the alignment and performance testing, the dial cord broke. Fortunately, its replacement wasn't all that difficult. I followed the original layout and within a few minutes, the dial drive was back in operation.

Performance

This radio was obviously designed for use in locations that were somewhat remote from radio stations, as it is unable to handle strong signals from local stations. However, its sensitivity is extremely good and signals of the order of just a few microvolts are heard quite clearly on both the broadcast and shortwave bands.

Cabinet clean-up

Although rather grubby, the cabinet was in quite good condition. First, I removed the "Monarch" badge from the front of the cabinet by undoing the nut on the inside. This badge is in two sections: a "crown" which I cleaned with a small wire brush and a main section which was cleaned with automotive cut and polish. It now looks quite presentable.

The polarity labels (mentioned earlier) were also cleaned with automotive cut and polish. This also removed the paint, so they were resprayed using black paint for the negative label and red paint for the positive label. Once the paint had dried, I used a razor blade to scrape it off the raised sections of the labels, so they now look just like they did when they were first made.

Next, the speaker cloth was removed from the cabinet, washed in soapy water and then laid out flat to dry. That turned out to be something of a disaster because it shrank too much to be refitted to the cabinet. As a result, a new piece of dark-brown speaker cloth was cut and glued into place.

That done, the cabinet and knobs were brushed clean of all loose dust and then scrubbed using a nail brush and soapy water to get rid of the surface muck. Some more automotive cut and polish and a polishing cloth brought the cabinet to life and made it look almost new. Unfortunately, however, a few scratches were too deep to remove without damaging the cabinet itself.

Summary

Because it isn't described in any of my service manuals and because the model number doesn't follow the normal Astor/clones sequence, I suspect that this receiver never went into full-scale production.

Another pointer to this is that all the knobs on the set have extended sleeves. However, this is necessary only for those knobs that have to reach the recessed control shafts beneath the protruding dial scale. By contrast, the other two shafts protrude beyond the cabinet and so the two lefthand controls sit quite proud of the cabinet.

In addition, the cabinet itself appears to have been designed for a different model. That's because the chassis mounting holes are not all in the correct positions.

These factors, together with the low-frequency instability and the inefficient valve heater circuits, all indicate that this might have been a pre-production receiver. It is similar to other 32V HT receivers from the same stable but it was obviously designed as an economy version. It doesn't handle strong signals at all well but is very sensitive and quite suitable for remote rural areas. The supply line is also poorly filtered and ripple on the line when the batteries in the power plant were being charged could have cause a "whine" in the audio output.

So the old Monarch has many design flaws, although these could have been addressed in a full production model. What a pity the manufacturer didn't do the job properly. **SC**

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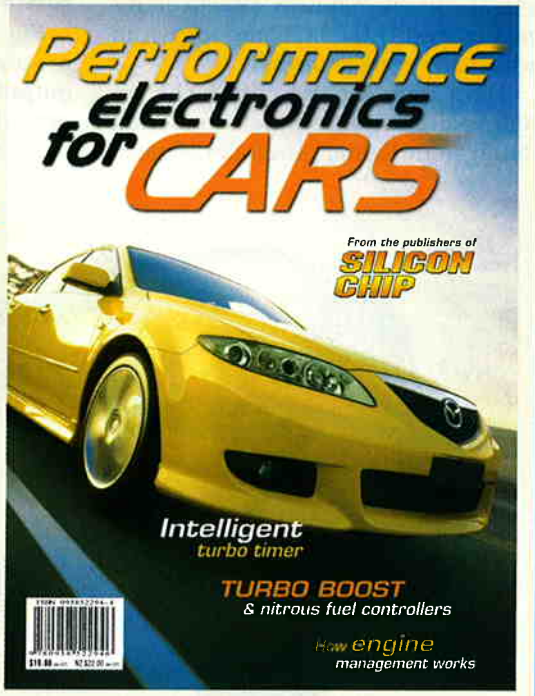
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BY JULIAN EDGAR

A $5 variable voltage power supply

Want to be able to dim lights in, say, a model rail layout? Or what about varying the speed of a low-powered motor or regulating the voltage going to a bike headlight, so that its brightness stays the same as the battery voltage falls? It's all possible for less than $5.00.

THIS DESIGN uses a slightly modified car phone charger. The idea is based on a Circuit Notebook contribution from Timo Mahoney in the November 2003 issue of SILICON CHIP.

Most car phone chargers use a DC-DC switching power supply to reduce the voltage from the car's 13.8V to what ever the phone requires. However, it's easy to modify the PC board to give an adjustable voltage output.

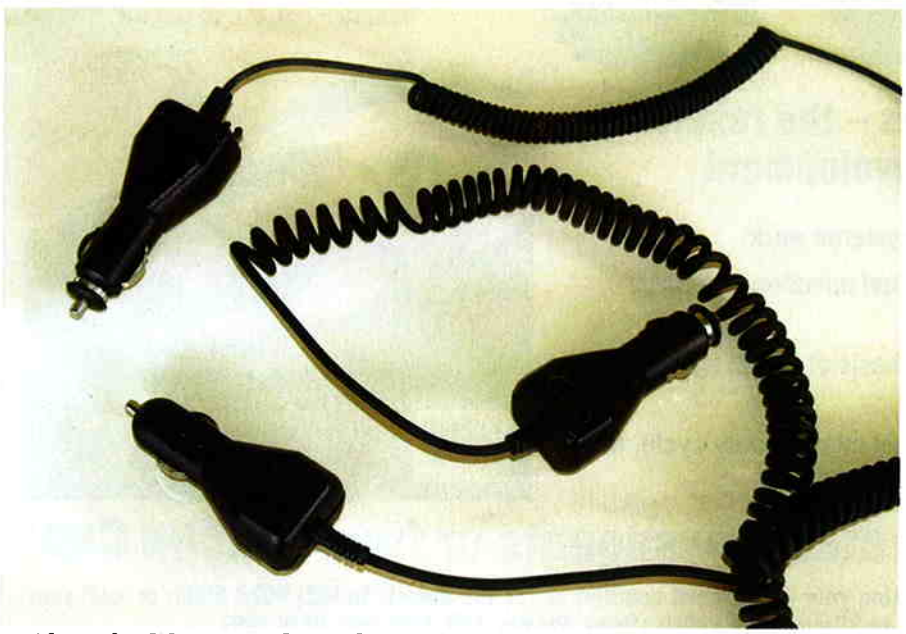
Apart from the car phone charger (the electronics are normally built into the cigarette lighter plug), all you need is a 10kΩ potentiometer. Car phone chargers are available in secondhand shops, at the tip and in the junk rooms out the back of phone retailers, while a 10kΩ pot can be scrounged from some old gear or purchased from your local electronics parts retailer.

Building it

Fig.1 shows a typical circuit for a car phone charger. The IC controls the output voltage, using voltage feedback provided by resistors R1 and R2. So if you change the values of R1 and R2, the voltage output will also change.

However, rather than have a fixed output, we can vary the output at will by installing an adjustable pot in place of the two resistors. Then it's just a case of measuring the output voltage and adjusting the pot until the required voltage is obtained. If you want the voltage to be set and then forgotten, use a trimpot. Alternatively, if you want to be able to vary the voltage at any time, wire a full-size pot to the board with flying leads.

The most difficult part is finding the correct resistors to change. Individual chargers vary quite a lot, so the com-



Inside each of these car phone chargers is a sophisticated DC/DC converter than can be easily modified to provide a variable output power supply.

Rat It Before You Chuck It!

Whenever you throw away an old TV (or VCR or washing machine or dishwasher or printer) do you always think that surely there must be some good salvageable components inside? Well, this column is for you! (And it's also for people without a lot of dough.) Each month we'll use bits and pieces sourced from discards, sometimes in mini-projects and other times as an ideas smorgasbord.

And you can contribute as well. If you have a use for specific parts which can easily be salvaged from goods commonly being thrown away, we'd love to hear from you. Perhaps you use the pressure switch from a washing machine to control a pump. Or maybe you salvage the high-quality bearings from VCR heads. Or perhaps you've found how the guts of a cassette player can be easily turned into a metal detector. (Well, we made the last one up but you get the idea . . .)

If you have some practical ideas, write in and tell us!

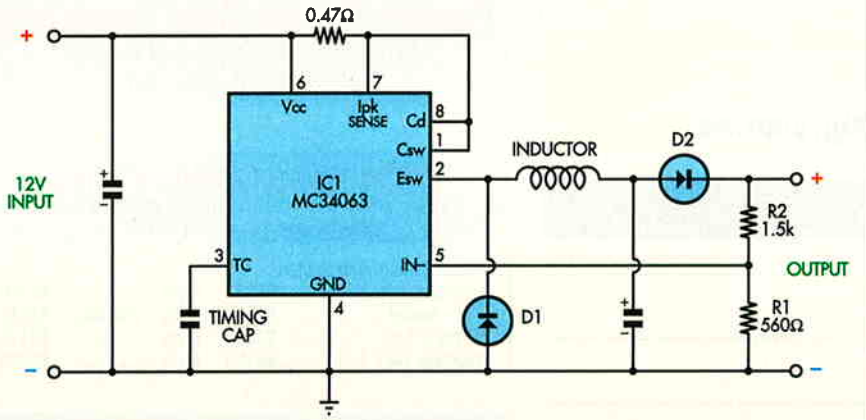
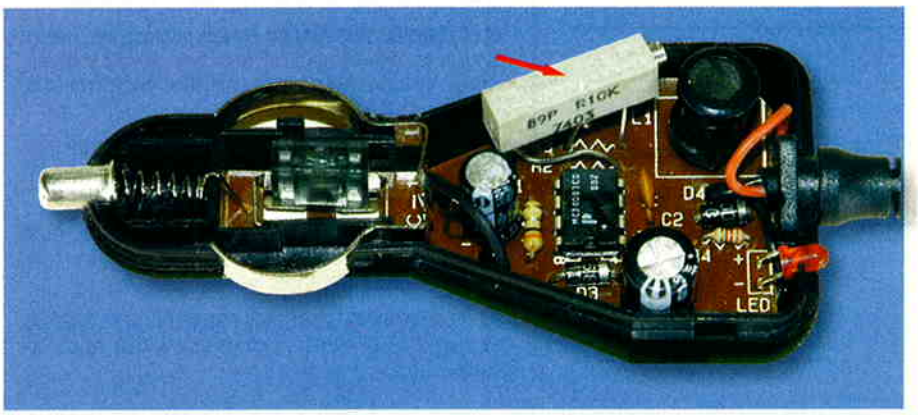


Fig.1 – the circuit of a typical car phone charger. The output voltage is set by R1 and R2. If these are replaced with a 10kΩ pot, the output voltage can be adjusted over a wide range.



The charger is modified to produce a variable output by substituting a pot (arrowed) for two resistors. If external adjustment is needed, a full-size pot can be wired to the board with flying leads. In this case, a multi-turn pot has been used, which allows for very accurate setting of the output voltage.

ponent designations marked on the board (R1, R2, etc) will probably not coincide with Fig.1. Hmmm.

So how do you find the right resistors? The answer is to closely look at the top and bottom side of the board. Somewhere, there will be two resistors that join to a common track at one end but go to different tracks at their other ends. The track that both resistors join to will also connect to pin 5 of the IC. Given that there will only be three or (at most) four resistors on the board, it shouldn't be all that hard to find the resistor pair in question.

The next step is even easier – remove these two resistors and solder the pot to the board in their place. The centre terminal of the pot goes to the track where the two resistors were originally joined together, while the outer pot terminals connect to the remaining two vacant pads.

Note that it, in some cases, it's easier to make the connections by soldering the pot to the track side of the board.

Each of these bike headlights is run from a modified phone charger. The chargers are used to drop the voltage from the available 12V (provided by sealed lead-acid batteries that also power the electric-assist bike) to a regulated 6V.

Using it

To test the modified power supply, you'll need a source of 12V power and a multimeter.

First, connect the power supply to the 12V source (eg, a plugpack), making sure that you get the polarity the right way around (the tip of the cigarette lighter plug is positive). That done, connect the multimeter to the output leads of the adaptor and measure the voltage as the pot is adjusted – the output voltage should vary.

Finally, place a load on the output (eg, a small 12V bulb) and check that you can alter the brightness of the lamp over a wide range. Typically, you can draw about 0.5A from the unit (depending on the plugpack). If the output voltage is critical, the pot should be set with the load attached. **SC**

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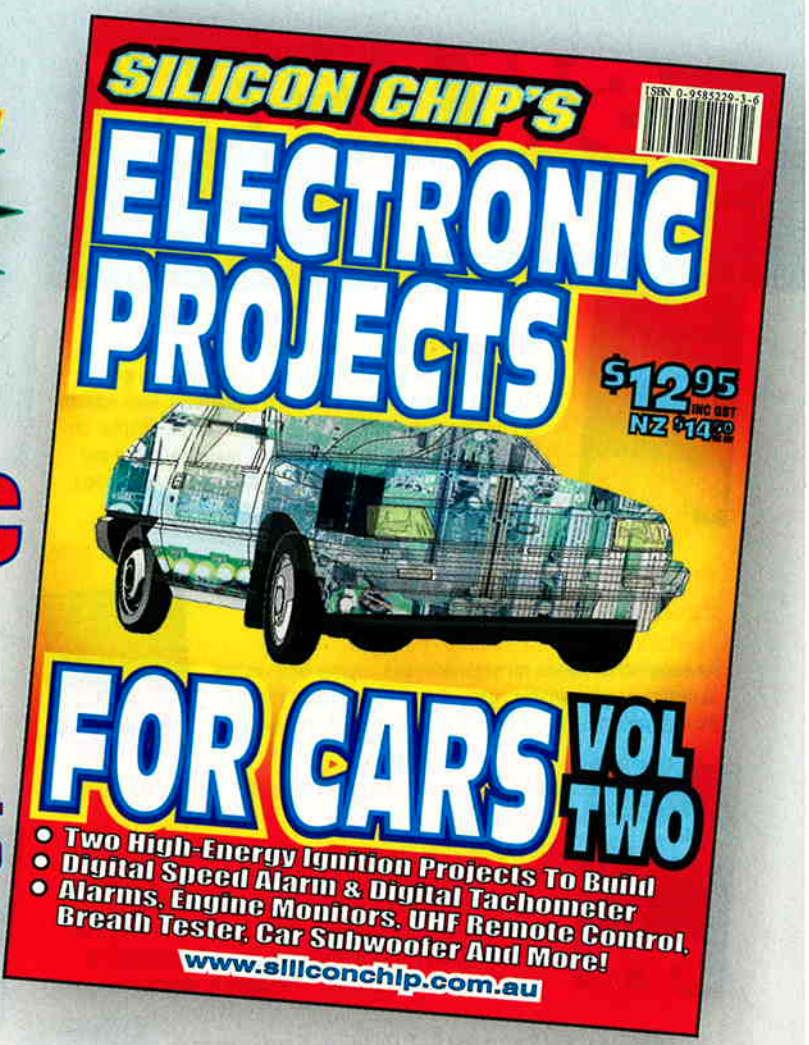
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Soldering surface mount ICs

I was interested in the Serviceman's technique for removing and replacing a surface-mount IC using a "flow soldering" approach (February 2005, page 50). Would it be possible for someone to spell out exactly how you do this?

There are a few SILICON CHIP projects which interest me but which I have so far not had the courage to attempt after reading the recommended way of soldering an SM IC.

The first problem I foresee is holding the IC in place while making the first soldered joint. Could this be done with a very temporary, quite weak, adhesive such as BluTak? What about then following this by "flow soldering" as described, followed by desoldering braid? (J. N., via email).

● First, we should mention that the Serviceman uses this "flow soldering" technique because he lacks the correct tools for the job, which would be prohibitively expensive if rarely used.

The technique will work on all fine-pitch surface-mount chips that have rows of pins on only two sides. The idea is actually quite simple, as follows:

(1). Short all the pins on one side together by bridging them with solder. This is done by applying a lot more solder than is normally necessary to each pin.

(2). Heat the IC to soften the glue that is used during assembly to hold it in place. Heat should also be applied to the opposite side of the PC board, under the IC. A hair dryer might be suitable for the job.

(3). Slip a fine-bladed instrument under one side of the IC and apply light upwards pressure.

(4). Heat the solder bridge formed in step (1), which should simultaneously melt the solder on all pins on that side.

(5). Lever the IC up to lift the pins away from their pads, just clear of the solder.

The second side can be removed in a similar manner. A desoldering tool or fine desoldering braid can then be used to remove excess solder.

Note that two disadvantages to this method are the possibility of damage to the PC board due to lifted pads as well as pin malformation of the IC itself.

We don't describe many projects employing SMD ICs because they can be very difficult to hand solder. In fact, most manufacturers do not recommend hand soldering for fine-pitched devices.

We described how to solder a 0.5mm-pitch device in the "High Efficiency Power Supply For 1W Luxeon Star LEDs" project in the January 2004 edition. As you point out, one of the more difficult parts of the job is locating and holding the IC precisely over its pads. Unfortunately, short of using commercial rework gear, we know of no easy way this can be achieved.

Improving A 240VAC Inverter's Output

I have a question or two for an expert in electricity.

Recently, I have been powering my 240VAC 0.9A 50Hz freezer from a modified sinewave inverter (12V DC input, 1500W continuous). I also have an 8µF 400VAC capacitor from an old water pump (240VAC 2.5A 50Hz).

Would there be any advantage in making a junction box with the above capacitor connected to the Active (as it was with the water pump) to:

(1) Reduce the surge maximum on the inverter, therefore making 1200W available for other applications during fridge start up?

(2) Improve the quality of the modified square wave supply by smoothing out the signal? I don't have an oscilloscope! (A. M., via email).

● We would strongly recommend against connecting any capacitor across the output of your inverter. It will increase the harmonic currents from the inverter and will actually increase the total load current. It will also increase the initial surge current, if it is installed as part of the freezer.

It may smooth the waveform somewhat but there will be no benefit since your freezer motor naturally blocks the harmonics of the waveform and draws current mainly at the fundamental frequency.

Marine TV antenna

I have a question which relates to life on-board a yacht. How can I automatically keep the TV antenna pointing at the transmitter while the boat yaws about from the influence of winds and tides? I guess if cost is no problem, that a kind of auto-pilot arrangement with fluxgate compass, feedback unit and motor would do it? Or maybe some kind of gyro? Any ideas? (P. R., via email).

● We are not sure how you would solve that problem. You would first have to find the correct heading for the antenna (could be difficult, if you don't know where the transmitter is) and then maintain it. A servo circuit controlled by an electronic compass would do the job but we have not published anything in this area.

Ozone generator wanted

I am trying to find an ozone generator kit, to produce ozone. I understand that SILICON CHIP or EA did one a long time ago. (K. R., via email).

● No magazine that we know of has ever produced an ozone generator. We

assume you are referring to a negative ion generator. These had the undesirable side-effect of producing ozone which is why EA and SILICON CHIP never produced one. ETI magazine did produce a negative ion generator in the April 1981 issue, however if you wanted it specifically to produce ozone, say for a sterilisation application, it would not be very effective.

To produce reasonable amounts of ozone in a corona discharge, you would need much higher voltages than the 3kV generated by a negative ion generator.

We can supply the negative ion generator article if you want it. Photocopies of SILICON CHIP, "Electronics Australia" and "ETI" articles are available from Silicon Chip Publications for $8.80 each including GST and P&P (Australia) or $A10.00 each including airmail P&P (outside Australia). It is the same price for a back issue if we have it in stock.

Lost RFID tags require system reprogramming

I want to build two RFID units (SILICON CHIP, June 2004) for our shop to activate and deactivate our alarm system and as an automatic door lock for our rear door. As we share the premises with a Subway store, there would be around 15 tags in circulation.

The question is, if a tag was lost (very likely to happen) is there a way to eliminate that tag's number from the RFID module? From what I can see, you need the tag to delete it from the module. (P. D., Marshall, Vic).

● The only way to remove a lost tag is to erase the entire memory and reprogram the tags again. You may need a more comprehensive system for your application. Commercial units with keypads and/or computer connections that allow editing of tag codes are now available. You'll find some examples at: **www.microgram.com.au**

Magnetic field strength meter

I am trying to find a kit that was available about eight years ago. It was a digital EMR meter kit which discriminated between 50Hz and 60Hz and measures in nanoteslas, microteslas and milliteslas. This instrument could also pick up harmonics and it factors in all radiation, not just primary frequencies. Can you help me? (P. B., via email).

● The project was probably the Magnetic Field Strength Meter published in October 1991. No kit was produced but the parts should all still be available.

Concern about hot components in SC480

I recently constructed two of your SC480 amplifier modules (January & February 2003) and they sound great! However, after only perhaps half a minute of operation, Q4 and Q5 get very warm.

For peace of mind, I have wedged a small heatsink between the two and affixed them using thermal compound (to the heatsink) and hot glue (to the PC board). Nevertheless, the transistors still remain hot at around 55°C (with the heatsink). I realise that this is within the operating limits of the transistor but such a temperature rise (in excess of 30°C) is much higher than I expected.

Q6 also seems to get quite warm at around 60°C but according to your schematic, there is around 38V across it. In addition, the 1W resistors which are raised around 3-5mm off the PC board on the power supply board get very warm as well (around 60-65°C). I am not powering anything from this ±15V power supply. Is this temperature to be expected? The output transistors do NOT get hot.

I know that most of these temperatures are (well) within devices' operating limits, so perhaps the thought of the lot "blowing up" and the financial distress involved enforces this need for reconfirmation. I hope that you can tell me if these temperatures are to be expected. (Y. P., via email).

● Q4, Q5 & Q6 have to dissipate about 0.33W and will therefore get quite warm in normal operation. As you point out, this is within the operating parameters of the transistors and therefore no heatsinking is required.

The 2.2kΩ 1W resistors on the power supply board each dissipate about 0.28W. Again, these resistors will get quite warm. Check that the output voltages are correct (±15V), as overheating can be caused by accidental reversal of the zener diodes.

Assuming that all of the DC voltages around the circuit approximate those shown on the circuit diagram, you can be reasonably confident that all is well and your investment is not about to disappear in a puff of smoke!

PortaPal plagued with hum

I have recently built the PortaPal portable PA system described in the February & March 2003 issues but have problems with it. With a good battery and mains plugpack connected, I get loud hum and "motor-boating". If the plugpack is disconnected, the noise goes but of course, there is no earth and the (unbalanced) microphone produces bad hum.

With the plugpack connected but with low battery volts (11V), I get no noise so the problem is voltage-dependent. Has anyone else experienced problems with this circuit? Are there any notes/errata I should implement? (J. W., Gladesville, NSW).

● We published Notes & Errata in the April 2003 issue to the effect that the 10µF at the adjust terminal on the REG1 (charger circuit) should not be used in the PortaPal. This is because it can cause the problems you are experiencing.

Also check the stability of the amplifier. It may have a faulty decoupling capacitor.

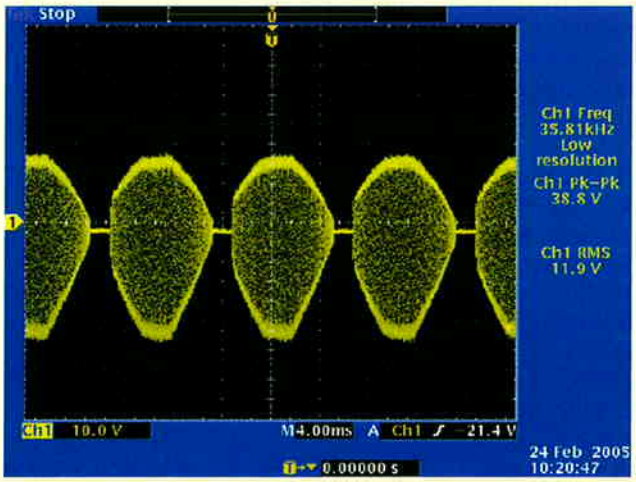
High cost can make TV sets unrepairable

Is it normal for TV sets which require a new yoke to be unrepairable? My NEC FS 6331 has a faulty yoke and I was told to throw it out and purchase a new TV as new yokes are not available without a new picture tube.

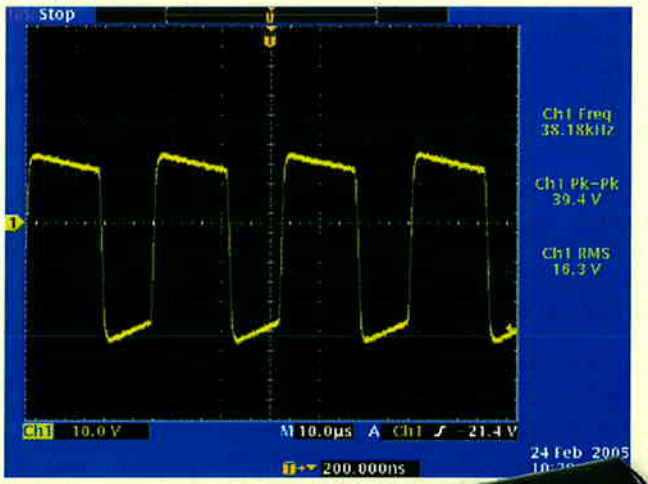
If this is the case, could you please offer an opinion as to a brand and model of TV you consider reliable and well made, etc. (P. B., via email).

● We ran your question past our Serviceman writer for his response and he

Solid-State Transformers No Good For DC



Waveform A



Waveform B

I have purchased a 240/12V solid-state transformer for use with a 50W halogen lamp. I want to rectify the output to give DC. I have used a 6A bridge rectifier but it gets extremely hot and drops about 5V across it.

Is there some reason why the output of these power supplies cannot be rectified? (G. H., via email).

● These so-called solid-state transformers are, in effect, high-frequency switchmode power supplies with an AC output. They are set to deliver 12V RMS to the halogen lamp but their peak output is a lot higher than that so you can't use them to produce a given value of DC. Nor will ordinary rectifiers work with them, as you have found, as the switching frequency is very high at around 40kHz. Nor can they drive a standard rectifier/capacitor combination.

The accompanying waveforms show the operation of a typical 50W solid state Halogen transformer. In waveform A, the scope sweep speed is set to 4ms/div to show the 100Hz modulation of a high-frequency waveform. This has an RMS value of 11.9V – ideal for a halogen lamp but useless for anything else.

In waveform B, the scope sweep speed is set to 10µs/div so we can see the high-frequency waveform without the modulation. In this case it is running at about 38kHz. Note the peak-to-peak voltage of 39.4V. So the unit is quite useless if you want to use it to produce a given value of DC.

replied, as follows: often, the deflection yoke is only sold as an integral custom-built part of the picture tube. In this case, this set uses a Thomson picture tube A63ADT10X505 which has the yoke (I believe!) cemented on to it (part no 33026904). I guess if you want to spend about $1000 on a 10+ year old TV, it can be repaired.

I cannot guess which brand of TV currently on sale is the most reliable – only time can tell.

Charging deep cycle batteries on a boat

On my yacht, there are two deep-cycle batteries that are charged by the diesel alternator. We stay away for periods of up to a week and when at anchor, the internal system runs on one battery with the other held in reserve so that we are able to start the diesel.

Looking at the circuitry in the Deep Cycle Charger (November & December 2004), it would seem that if two chargers were built with input from the rectified output of the alternator, the advantages of the designed charging cycle could be obtained. I assume that the display could be switched between the two controllers.

I would be pleased to have your comments. (J. R., via email).

● You can use the one alternator to drive both chargers. The display could be switched between chargers by switching the data and control lines. It would require a 6-pole 2-way rotary switch. It might be easier to have two displays to avoid the switching.

Help needed with Speedo Corrector

I have constructed a Speedo Corrector kit from your book "Performance Electronics for Cars" and cannot get it to work.

Several experts have followed the decision diagram to no avail. We have installed LK1 at X, gone to procedure 2 and installed R2 and LK3 at Y. No output signal to the speedo results. The speedo and sender are from a 1991 Toyota Corolla Levin AE101 import. What is wrong? (J. O., via email).

● First, make sure that the speedometer still works without the corrector.

Then, when the corrector is connected, check for voltage at the signal input and output. In your case, with LK1 at X and LK3 at Y and R2 installed, the voltage at the signal input should be around 6-7V (multimeter set to DC volts) and the same voltage should be at the output.

If this is not the case, check through the procedure again. Make sure the correct resistor (R1 or R2) is installed and that the setting for LK3 is correct.

How to motorise Santa

We decorate our house at Christmas and have a motorised Santa that pops in and out of a chimney. This unit is home-made and is powered by a 12V DC windscreen wiper motor.

I made this decoration some four years ago and it operated fine. It was run on a motor-bike battery that had some dead cells. However, this battery was totally "gone" by the next year and upon trying a car battery or even a good bike battery, the whole thing runs too fast. Can you suggest a circuit that will slow the motor's speed while still leaving enough power for it to turn and lift the decoration? (P. M., Tuggerah, NSW).

● Have a look at the 12/24V speed control from the June 1997 issue. It should do the job.

NAND Schmitt gates explained

I wish to know what the four lines in middle of a NAND gate symbol mean. When I did my amateur course, we were only informed of the four types of gates. So what is the significance of the NAND gate symbols featured on page 69 (Circuit Notebook) of the December 2004 issue? (G. A., via email).

● The symbol you refer inside gates and inverters indicates that the device is also a Schmitt trigger. In fact, the symbol indicates the square hysteresis curve of the input signal.

Different crystal for Big Digit Clock

Can a 4.194304MHz crystal be substituted for the 4MHz crystal in the Big Digit Clock featured in the March 2001 issue? The way I read and look at it, in theory when the adjustment cycle is on zero, timekeeping with the 4.19MHz crystal would be nearly spot on. Not knowing the code inside the chip, I thought I would ask. (B. H., Creswick, Vic).

● If you use a 4.19 MHz crystal, the time-keeping will be much too fast. Admittedly, the binary set crystal frequencies are easier to divide down to 1Hz using discrete logic but when using a microprocessor, the division can be done using standard crystals and dividing by non-binary numbers will obtain an exact 1Hz signal.

The adjustment available in the clock is to allow for the crystal inaccuracy (typically 50 parts per million).

Auto-start on deep cycle charger

With reference to the Deep Cycle Battery Charger (November & December 2004), I would appreciate clarification of the auto-start function. Were I to build the charger, I would find this a useful facility as I would normally want to charge a deep-cycle battery but would occasionally want also to charge a starter battery (Specific #1) which I understand I can do with the link removed.

However, does the PIC controller remember the last charging cycle selected or revert to "normal" parameters as distinct from Specific #1 on a future charging cycle?

I would guess this comes down to whether the control out pin gets its data from EEPROM or RAM. (J. A., via email).

● The charger remembers the last settings and uses these during the auto-start feature. If you decide to change them, just press the set switch when power is first applied to the charger and change settings. The settings are in EEPROM and so are stored until changed. **SC**

Notes & Errata

Pool Lap Counter, March 2005: on the circuit diagram (Fig.1), the seven outputs from the 4511B (IC3) are shown connected to the LED array in reverse order. For example, pin 13 of IC3 should go to pin 7 (segment "a") of the LEDs, pin 12 of IC3 to pin 6 (segment "b") of the LEDs, etc.

Also, the decimal point (pin 8) of DS1 is shown connected to ground via a 1.5kΩ resistor. Instead, this resistor should go to the +12V rail.

The overlay diagram (Fig.2) and PC board (Fig.4) are correct.

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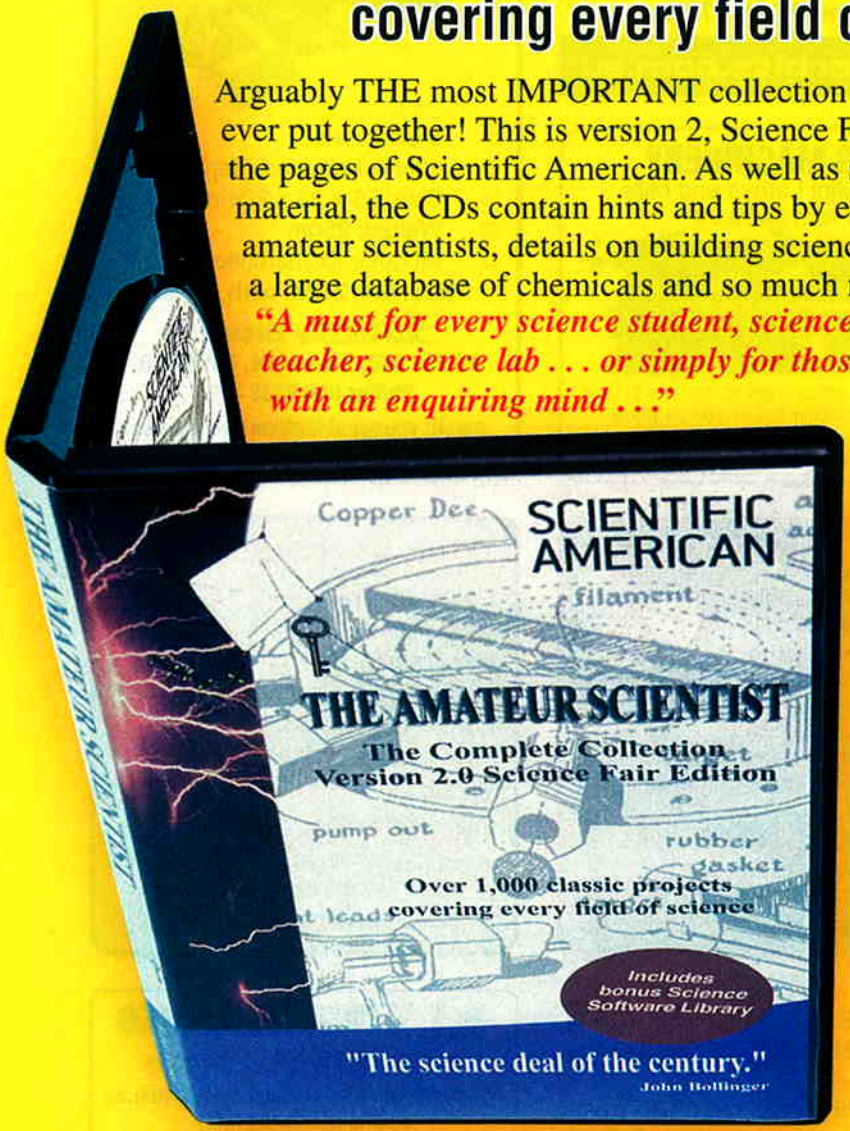

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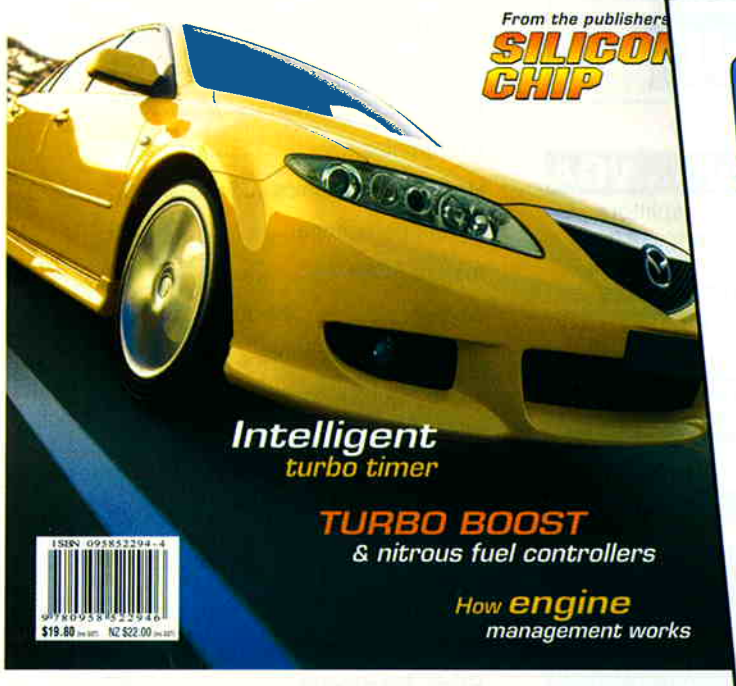

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72 **CHAPTER 12: Simple Voltage Switch**
Switch devices on and off using the sensors already under the bonnet – lots of uses from water-spray and fan control to nitrous oxide switching

77 **CHAPTER 13: Temperature Switch**
A cheap general-purpose adjustable design that can work all the way up to 245°C

We'll let the contents speak for themselves:

- **Not a reprint – new projects and articles not published before**
- **Learn how engine management works**
- **Build projects to control nitrous, fuel injection and turbo boost systems**
- **Switch devices on and off on the basis of signal frequency, temperature and voltage**
- **Build test instruments to check fuel injector duty cycle, fuel mixture and brake and coolant temperatures**

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